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ADVERTISING RATES GIVEN ON APPLICATION.

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THE INTERNATIONAL ELECTRICAL CONGRESS.

It should be a matter of congratulation to the whole electrochemical fraternity that Section C (Electrochemistry) will be one of the strongest sections of the St. Louis International Electrical Congress. The programme of this section is an excellent one and contains papers by the foremost representatives of electrochemical science and art. Moreover, the steadily increasing influence of electrochemistry manifests itself occasionally in the programme of the other sections. It was an unselfish but a very wise policy of the officers of the American Electrochemical Society to decide to hold only one independent session and otherwise to further with all means the success of the Congress. There can be no doubt that the result will be most gratifying to all who will attend the Congress and will further the common cause in which electrochemical engineers and scientists are alike enlisted.

USES OF ELECTROLYTIC CHLORINE.

In the production of caustic soda and bleaching powder by electrolysis of common salt, electrolytic methods have achieved a most significant success. In this field electrochemistry came into direct competition with one of the best established and technically the best developed of the chemical industries, and electrochemical methods came out victorious. Moreover the great variety of possible methods at the disposal of the electrochemist is emphasized by the fact that the principal technical problem in the present case—to keep the anodic chlorine separated from the NaOH formed at the cathode—has been solved in various essentially different ways: first, by absorbing the discharged sodium ions by the cathode and thus removing them out of the sphere of chlorine, either by the use of a cathode of mercury (Castner-Keller) or of fused lead (Acker); secondly, by separating the anode compartment from the cathode compartment by means of a diaphragm; thirdly, by keeping the anolyte separated from the catholyte by gravity, making use of their different specific gravities (Glocken process). However, this success of electrochemistry in the manufacture of caustic soda and chloride of lime has been rather an engineering success than an industrial success; that means, while all difficulties in the methods of manufacture were successfully overcome, the financial result has not been correspondingly encouraging. The trouble lies on the chlorine end of the business, there being very little profit in making bleaching powder in the present state of the market. If all the electrolytic chlorine is used for making bleaching powder, the output of bleaching powder is chemically equivalent to the output of caustic soda—but no corresponding industrial law rules the demand for both products. Possibly an agreement between the various manufacturers as to the selling price of bleaching powder might temporarily help matters. But a radical remedy would be the resolution of our manufac-

turers to make only as much bleaching powder as they can sell at a good profit, and to utilize the excess of chlorine for making other valuable products. In this respect the article of Dr. F. Winteler, published in our present issue, is highly suggestive and should give valuable hints to our manufacturers, since the majority of the products described by Dr. Winteler were made by him on an industrial scale from electrolytic chlorine. Especially the possibility of making organic compounds seems interesting. Here we have an opening for a natural growth of industrial organic chemistry on American soil. American electrochemists have always distinguished themselves by enterprise and power and spunk. It would not be surprising if the commercial troubles which our manufacturers have with their electrolytic chlorine would lead to important industrial advances in the line of organic chemistry in this country. There is no reason whatever that the United States should be an importer of organic compounds all the time.

ELECTRIC FURNACE DESIGN.

The first electric furnaces in which the fundamental pioneer work was done, were necessarily of rather crude design; but they were sufficient to bring out forcibly one fundamental point, namely, that it is possible to produce by means of the electric furnace very high temperatures not attainable by other means, and thus to start new reactions and obtain new compounds. Later on electric furnace design passed through an extended experimental and theoretical development, and is now based on exact scientific principles, like the design of dynamos or steam engines. To operate an electric furnace process industrially to the best advantage, the furnace must be so designed that the rather costly electrical heat is utilized and concentrated at exactly the point where it is needed, and that the temperature is under the absolute control of the operator. The details of electric furnace design are at present the property of a relatively small number of electrochemical inventors and engineers who have worked them out, and it is quite natural that they are not disposed to give them to the public. While it is thus possible that the day is far off when all details of electric furnace design will become public property of the electrochemical fraternity, yet there is no reason that the principles of the design and manipulation of electric furnaces should not be now within the reach of anybody who wants to work in this line. But information in this direction has so far been rather scattered and inaccessible.

While the first electric furnace experiments were made with arc furnaces, the tendency has, in recent years, been to develop the electric resistance furnace, on account of the great ease with which the temperature can be controlled in the same. A convenient special type is that in which an electric current is passed through a resistance material and the electrical energy converted into heat which does useful work. We are glad to announce that we will publish a series of articles on the construction and manipulation of this type of furnace, by Mr. F. A. J. FitzGerald, who has been intimately connected with the development of this type for many years. The intention is to discuss the principles on which furnaces of this kind are designed, and then to go into details of construction, and to give hints how experiments may be carried out on a small scale without costly or complicated apparatus. We have no doubt that this serial will be welcome to many of our readers, and will help to assist the useful growth of industries which may advantageously use this type of furnace. The first article of Mr. FitzGerald's serial is published in our present issue and deals with some first principles. We like to call attention to one point forcibly brought out by Mr. FitzGerald. It is that the heat generated at a point depends on the watts per unit of volume, while it is ordinary but objectionable practice to give the current density in amperes per unit of cross-section. This latter figure, however, does not determine the temperature unequivocally, since the conductivity of the resistance material is to be taken into account, and even if the same resistance material is used throughout the furnace, the conductivity may vary according to the greater or smaller degree in which the resistance material is compressed at different points of the furnace.

CONTACT PROCESSES AND ELECTROLYSIS.

Catalytic action has long been known. We designate by this name all phenomena in which a substance (catalyzer) must necessarily be present if a certain reaction is to take place, although the catalyzer apparently does not participate in the reaction. Since it seems to act simply in virtue of its contact with the reacting substances, we speak of a contact process. A satisfactory explanation of catalytic action has not yet been found, nor does it seem probable that the same explanation will apply to all different kinds of catalytic action. But we are sufficiently acquainted with the catalytic property of various substances to utilize it in practice. In the special case of the manufacture of sulphuric acid, the introduction of the contact process has nearly brought about an industrial revolution. An interesting article on the contact process for making sulphuric acid will be found on another page of this issue. Here we wish to point out briefly for what purpose catalytic action might be utilized in electrolysis. If at an electrode a number of reactions are possible, these reactions will start one after the other, when the voltage is gradually raised, since each reaction requires a distinct minimum voltage, proportional to the free energy of the reaction. If the voltage is sufficiently high, several electrochemical reactions will simultaneously occur. Of course, what we may call the speed of the total chemical reaction (measured in the number of all gramequivalents, together undergoing reduction or oxidation at the two electrodes, per second) is directly given by the current in amperes, according to Faraday's law. But this law does not determine to what extent the different single possible reactions will take place. It is at this point that calatyzers might prove useful, as may best be seen from the point of view of Ostwald, who considers as the characteristic feature of a catalyzer its influence upon the speed of a reaction. There are "positive" catalyzers which increase the speed of a reaction, like platinum in the sulphuric acid contact process, and there are "negative" catalyzers, which tend to retard the speed of a reaction. By judiciously using either positive or negative catalyzers in con-

nection with the electrolytic reaction at an electrode, it would appear to be possible to force the current to select the one desired reaction out of a number of possible reactions. In fact, working on this basis, Ostwald and Luther have done elaborate and extended laboratory research work, so that Pfof. Ostwald's paper to be presented at the St. Louis Congress, on this subject, should be expected to contain interesting information. It is by no means impossible that catalytic action may play an important part in future in industrial electrolytic processes.

RECENT DEVELOPMENTS IN ZINC METALLURGY.

Many attempts have been made to accomplish improvements in the metallurgical working of zinc ores, by applying electrochemical methods. Electrolysis has chiefly been resorted to, but no electrolytic method has been a commercial success on a large scale in the past, though most of the engineering difficulties were cleverly overcome. A special problem of considerable industrial importance is the production of zinc from complex sulphide ores. Two new electrolytic processes attempting to solve this problem have recently been tried on a larger scale. The one is Swinburne and Ashcroft's "chlorine smelting" process, which was described at some length in our August issue of last year. The scheme is to first treat the ores with hot chlorine in order to change the sulphides into chlorides, then to treat chemically the mixed chlorides by substitution in order to replace all other metals by zinc, finally to electrolyze the fused zinc chloride. Recent developments of this process will be dealt with in a paper to be presented by Mr. Swinburne before the Electrical Congress in St. Louis. A second process which has recently been tried on a larger scale is that of Mr. Burleigh, who describes it in an interesting article published in our present issue. After preliminary metallurgical treatment, he dissolves the metallic contents of the ore in a "soda solution" and first wins lead and then zinc by electrolysis. Mr. Burleigh appears to have successfully overcome all main difficulties, so that further and more detailed information concerning some phases of the process which are dealt with somewhat briefly in his present article are to be awaited with interest.

Little has been done commercially with the electric furnace in the zinc industry, though the two brothers Cowles, in their early experiments, used the electric furnace for zinc distillation. In recent years de Laval is reported to have designed and to operate an electric arc furnace (somewhat of the type of the Moissan furnace) for zinc distillation on a larger experimental scale in Sweden. It would appear that the electric furnace should have distinct advantages for this purpose. In our present commercial zinc distillation plants, with their expensive retorts and with the essential necessity of applying external heat, the fuel really consumed is greatly in excess over that theoretically required. In the electric furnace we can generate and concentrate the heat at the spot where it is needed. But if we consider that heat generated from electrical energy is rather expensive, it will be clear that if electric furnace methods shall succeed in the zinc industries, the furnace must be carefully designed with due respect to all special requirements of zinc distillation.

In the meantime numerous experimenters continue trying to solve the problem of smelting zinc ores in the blast furnace. It has long been known that the process is not at all theoretically impossible, and attention has been called to the fact that occasionally metallic zinc is formed as a by-product in blast furnace plants for the treatment of zinciferous iron and lead ores. But whenever the blast furnace has been applied directly for zinc production, the zinc has not been obtained in liquid form, but in form of a powder of zinc, mixed or not with zinc oxide. The reason is that when zinc oxide is reduced in the blast furnace, the vapor is always diluted with the nitrogen of the air (which will cause the zinc to be obtained in dust form) and with the combustion products of the fuel and unconsumed air (which will cause immediate reoxidation). By an interesting method described in this issue under "Recent Metallurgical Patents," Dr. O. Nagel proposes to carry out the distillation of zinc from ore, mixed with coal, in the atmosphere of natural gas, which acts as a reducing agent. Dr. Nagel had formerly proposed to use water gas, preferably preheated before introduced into the furnace. Coal is mixed with the ore, so that any gases shall be reduced which may become oxidized by the reduction of zinc oxide. The zinc vapor may then be obtained in such a concentrated condition as to condense to spelter. The main point in Dr. Nagel's new patent is that coal gas and natural gas are equal and sometimes superior to water gas. It will thus be seen that there is at present a great activity among zinc metallurgists and that the tendency in general is not to look for improvement of details of the present metallurgical methods, but rather to open new avenues of progress.

EFFECT OF ALTERNATING-CURRENT FREQUENCY IN ELECTROCHEMICAL WORK.

If it is intended to produce a chemical effect by sending an alternating-current discharge through a gas, it is quite evident that the frequency must be high enough, and it seems reasonable to expect the best results if the frequency is between certain limits. For instance, in a patent recorded in our April issue, Kowalski reports that for the production of nitric acid from air the best frequency is between 6000 and 10,000 alternations per second. If an alternating current should be used for producing electrolytic decomposition, it is also quite evident that the frequency will have a decided effect. In this case it should not be too high, since the lower the frequency, the greater is the chance for the products of electrolytic action, obtained during one-half wave of the alternating current, to be removed from contact with the electrodes so that they are not changed back into the original state during the next half wave. In electric furnace processes it has, up to the present, always been assumed that the frequency has no influence. But from a patent of W. S. Horry, abstracted in this issue, it appears that a higher frequency has a distinct beneficial effect in the production of calcium carbide. The explanation, given by Mr. Horry, seems quite reasonable. It is that the furnace charge undergoes electrolytic decomposition if the frequency is too low—and this means, of course, a diminished efficiency.

AMERICAN ELECTROCHEMICAL SOCIETY.

The meeting of the American Electrochemical Society will be held in St. Louis on the 13th, 15th and 16th of September. On the 13th and 15th joint sessions will be held with Section C (Electrochemistry) of the International Electrical Congress, while on the 16th an independent meeting will be held which is designated as a joint meeting with the Bunsen and Faraday Societies, and to which the members of the Congress will be invited.

A local committee of the Electrochemical Society has not been appointed, but the following St. Louis members will be glad to answer inquiries: Mr. C. D. Chasteney, De Laval Steam Turbine Co., Mining Gulch, Exposition Grounds, St. Louis; Mr. F. E. Drake, President Lanyon Zinc Co., 607 Carleton Building, St. Louis; Prof. W. E. Goldsborough, Chairman Department of Electricity, World's Fair, St. Louis; Mr. Carl Hambuechen, Pittsburg Reduction Co., East St. Louis.

The official delegate of the Bunsen Society is Dr. Hans Goldschmidt of Essen-Ruhr, Germany, who, on request of the Congress authorities, will deliver a lecture on aluminothermics, with numerous demonstrations, at one of the evening sessions. Provisionally, the date has been fixed for Sept. 13, and as place the hall of the Westinghouse Co. will be used.

The Faraday Society will be represented by four official delegates: Prof. F. G. Bailey, Heriot-Watt College, Edinburgh; Mr. Sherard Cowper-Coles, London; Mr. J. S. MacArthur, London, and Mr. E. K. Scott, Beesfield, Farmingham, Kent.

The Electrochemical Congress papers (to be presented on Sept. 13, 14 and 15 before Section C) are printed on another page of this issue. At the session to be held on Sept. 16, Prof. F. G. Bailey, of the Faraday Society, and Dr. Hans Goldschmidt, of the Bunsen Society, are expected to read papers, the titles of which are to be announced later. There will also be presented papers by members of the Electrochemical Society, among them Prof. W. D. Bancroft on the aluminium rectifyer, and Prof. H. E. Patten on an analytical study of the deposition of aluminium from ethyl bromide solutions.

Members are requested to register at the Coliseum as soon as they arrive, on Saturday, Monday or Tuesday. Badges of the Electrochemical Society will admit members to the independent meeting on September 16th, and to the joint meetings with the Congress on the 13th and 14th, but not on the 15th, unless members of the Congress. Application for membership to the Congress (fee $5.00) will be received up to the close of the exercises on Sept. 17.

A *Dinner Rendezvous* is being arranged to be held at a popular restaurant in the World's Fair Grounds at 6.30 to 7.30, on the 13th, 14th, 15th and 16th. It will probably be at the Tyrolean Alps Restaurant at the portion of "The Pike" next to the Main Entrance, the cost not to exceed $1.50. This is in lieu of a banquet, as it is believed it will be better appreciated.

SOCIETY OF CHEMICAL INDUSTRY.

The Society of Chemical Industry will hold its annual general meeting in New York City from September 7th to 11th. This will be the first general meeting held in America, and a most elaborate programme has been arranged, a general outline of which was given in our April issue, page 148, which will be fully carried out, all arrangements having been completed. Over eighty (sixty-seven gentlemen and fourteen ladies) from abroad have already signified their intention of accepting the invitation of the New York Section of the Society of Chemical Industry, and this list is being added to from time to time, and it is hoped that the final number will be not less than 100. The expense of entertaining members from abroad while in New York, and for the cost of their transportation and sleeping accommodations on the round trip through the country is covered by subscription by the New York Section. On the round trip the following places will be visited: Philadelphia, Washington, Pittsburg, St. Louis, Chicago, Detroit, Buffalo, Niagara Falls, Boston and back to New York. For the visits of these places, a most elaborate programme has been arranged. The members participating in the trip will attend the congresses for Inorganic and Organic Chemistry, and for Technical, Physical and Physiological Chemistry in St. Louis on September 21 and 22.

The programme for the meeting in New York is as follows:

Wednesday, September 7th, at 9 p. m., at the Chemists' Club: Informal reception.

Thursday, September 8th, at Columbia University: 10 a. m., council meeting. 10.30 a. m., general meeting; address by Sir William Ramsay. 1.00 p. m., informal luncheon at a place to be announced later. 2.30 p. m., seeing New York by stages and automobiles. 7.30 p. m., annual dinner.

Friday, September 9th: Visits to manufacturing establishments. 8.30 p. m., roof garden entertainment.

Saturday, September 10th: Visits to manufacturing establishments. 8.30 p. m., smoker at one of the New York clubs.

Sunday, September 11th: Excursion by steamer around New York, the Sound and up the Hudson.

Following is a list of manufacturing establishments and places of interest in and around New York to which visits will be made. An asterisk means that ladies are invited:

Westinghouse, Church, Kerr & Co., Power-house for Pennsylvania Railroad at Long Island City.

Consolidated Gas Co., Gas Works at Ravenswood, L. I. (Limited to 25.)

New York Edison Co., Waterside Station, Thirty-eighth to Thirty-ninth Streets and East River. (Limited to 25.)

Schwarzschild & Sulzberger Co., Abattoir, Forty-fifth Street and First Avenue.

Nichols Chemical Co., Copper Refinery at Laurel Hill. (For English members and invited guests only. Limited to 75.)

*Carl H. Schultz, Mineral Water Manufacturing, 440 First Avenue, New York City. (Limited to 50.)

New Jersey Zinc Co., Spiegel Furnace, Hackensack Meadow.

Ehret's Brewery, Ninety-second Street, near Third Avenue, New York City.

Ruppert's Brewery, Ninety-second Street and Third Avenue, New York City.

Central Brewing Co., Sixty-eighth Street and East River, New York City.

Pacific Coast Borax Co., Factory at Bayonne, N. J.

*Tiffany & Co., Jewels and Jewel Cutting and Setting.

*Metropolitan Museum of Art, Fifth Avenue and Eighty-second Street, New York City, Bishop Collection of Jade; Morgan Collection of Porcelains; Gold Room, etc. This will be followed by a luncheon at the Casino in Central Park, for which a charge of $1.50 will be made to American and Canadian members.

*American Museum of Natural History, Columbus Avenue and Seventy-seventh Street, New York City, Gem Room, Bement Collection of Minerals, etc.

Tartar Chemical Co., Ninth Street and Gowanus Canal, Brooklyn.

Tide Water Oil Co., Bayonne, N. J.

Balbach Smelting & Refining Co., 73 Passaic Avenue, Newark, N. J.

Murphy Varnish Co., McWhorter and Chestnut Streets, Newark, N. J.

F. W. Devoe & C. T. Raynolds Co. (Paints, etc.), 565 Smith Street, Brooklyn.

John W. Masury & Sons (Paints, etc.), 50 Jay Street, Brooklyn.

B. Moore Co. (Paints, etc.), 262 Water Street, Brooklyn.

The Congress of Chemistry in St. Louis will be part of the International Congress of Arts and Science, and will be subdivided into the four sections for inorganic, organic, physical and physiological chemistry.

SOME NOTES ON THE USES OF ELECTROLYTIC CHLORINE.

BY F. WINTELER, PH. D.

The most convenient method of utilizing electrolytic chlorine is, without any doubt, the manufacture of bleaching powder. Up to the present time all plants which make caustic potash or caustic soda by electrolysis, have also made bleaching powder.

Years ago, however, the danger was already recognized that in time an overproduction of chloride of lime would result, and this has now become a fact. As a result of this overproduction the price of bleaching powder has gone down to such an extent that there is scarcely much profit in its manfacture. Nevertheless, the works continue to produce chloride of lime for the reason that it is not feasible to let the chlorine gas escape into the air, while up to the present the manufacture of other products has been somewhat out of the line of work of these plants.

In the present state of affairs, however, it will be in the interest of manufacturers to consider the production of other compounds from their chlorine, since that plant which makes from chlorine the most valuable compounds, will also occupy the strongest position in the caustic alkali market.

BLEACHING POWDER.

A few remarks may be made on the manufacture of chloride of lime. Its production is convenient to factories, especially for the reason that chlorine passes from the electrolytic cells under atmospheric pressure. Plants which are correctly designed are even careful to produce a lower pressure in the cells. For this purpose the cells are placed on the second floor of the building, and the chloride of lime chambers, some four meters deeper, on the first floor. If for any reason a cell should get a leak, the chlorine gas which, on account of its higher specific gravity, passes downwards, will suck air with it, and there will be no smell of chlorine in the cell room. A mixture of chlorine with air is in no way detrimental to the manufacture of chloride of lime—on the contrary, it is advantageous.

Chloride of lime thus produced will contain 36 per cent of active chlorine if the following conditions are observed.

(1) The chlorine should be as dry as possible.

(2) The calcium hydroxide should be as dry as possible.

(3) The temperature during the reaction of the chlorine with the calcium hydroxide should not be higher than 35° C. This is easily accomplished by allowing the chlorine to suck in about 50 per cent of air before entering the calcium hydroxide chambers.

(4) No excess of chlorine should be introduced into the calcium hydroxide chambers. The introduction of chlorine should be stopped as soon as a test shows a content of 33 to 34 per cent of active chlorine. The chlorine gas, which is still in the chamber is then slowly absorbed and the content rises to 36 per cent. If more chlorine would be introduced in the meantime, the content of active chlorine would decrease, since the hypochlorite which already has been formed would be changed to chlorate by the chlorine, introduced in excess, even at a low temperature.

If, instead of calcium hydroxide chambers mechanical apparatus are used, the supply of fresh calcium hydroxide is so regulated that the analysis of the chloride of lime, taken from the bottom, just shows the correct content.

A content of carbonic acid in chlorine is not detrimental to the manufacture of chloride of lime, as long as the gas and calcium hydroxide are dry.

DETINNING OF TINNED IRON SCRAP.

With respect to the manufacture of other products by means of electrolytic chlorine, it would appear that the detinning of tinned iron scrap should be specially advantageous in the United States. The manufacture of tin plate cans, containing corned beef, condensed milk and all kinds of preserves, yields an enormous quantity of tinned iron scrap. Such scrap is also obtained from many other sources. One hundred kilograms of tinned sheet iron contain 2 to 3 kg. of tin; the scrap from tin cans contains somewhat more tin, on account of the solder.

If well-dried chlorine is passed at a temperature of 40° to 50° C. over such tin scrap, the tin is changed into liquid fuming tin tetrachloride, $SnCl_4$. This drops off and is collected in bottles. If the necessary quantity of water and ammonium chloride (NH_4Cl) is added, one gets "pink salt" ($SnCl_4 + 2NH_4Cl$) which is extensively used in cotton printing and silk dyeing (to make the silk ware heavier). From 1000 kg. tinned iron scrap about 40 to 50 kg. of tin tetrachloride are obtained.

It is interesting to note that the iron on which the tin was plated is not attacked in any way by dry chlorine at the temperature mentioned. Ferric chlorides is formed only at a temperature above 100° C.

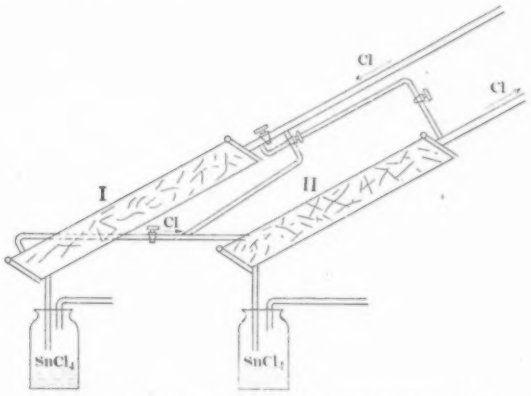


FIG. 1.—PRODUCTION OF TIN TETRACHLORIDE.

The process is carried out, as shown in Fig. 1, by filling the scrap from above into inclined iron tubes which must be absolutely dry. Two such tubes are connected in series and chlorine is passed through the same until no longer tin tetrachloride drops off from the first tube. Then air is blown through until all the chlorine has passed out of the first tube. The chlorine gas is now supplied to the second tube, while the first tube is emptied and refilled to be used now as second tube, and so on.

The pure iron thus obtained is melted in the Martin furnace, or may be usefully employed, especially in the United States, for obtaining cement copper from copper solutions. While tin scrap is useless for any other purpose, this process yields both valuable tin tetrachloride and valuable pure iron.

Tin tetrachloride, as obtained by the above process, may also be treated with water and afterwards with metallic zinc; this results in the precipitation of metallic tin and formation of zinc chloride. The former is melted, while the zinc chloride is used for impregnating wooden telegraph poles, railway ties, etc.

CHLORIDE OF SULPHUR.

Another compound which can be obtained from electrolytic chlorine is disulphur dichloride (sulphur monochloride), S_2Cl_2. It is used in the rubber industry in large quantities for vulcanizing India rubber.

In handbooks on chemistry it is stated that sulphur chloride is produced by passing chlorine through molten sulphur. The compound, however, may also be obtained simply by filling pieces of sulphur into a lead vessel and passing, at ordinary temperature, chlorine upwards through the vessel. An apparatus which has proven useful for the manufacture on a commercial scale is shown in Fig. 2.

It is entirely made of lead and consists of two containers which are filled with pieces of sulphur of rough surface, and through which chlorine is passed. The sulphur rests on a screen with large meshes. Below it, another screen is provided with smaller meshes, for catching any small pieces of sulphur falling down. The tubes below are protected by lead caps to prevent them from being clogged up by any solid matter falling down. Below the two sulphur containers, the vessel is provided for collecting the chloride of sulphur. It is so arranged that it may be easily emptied by compressed air. To take out smaller quantities without compressed air, a spigot is provided at the bottom.

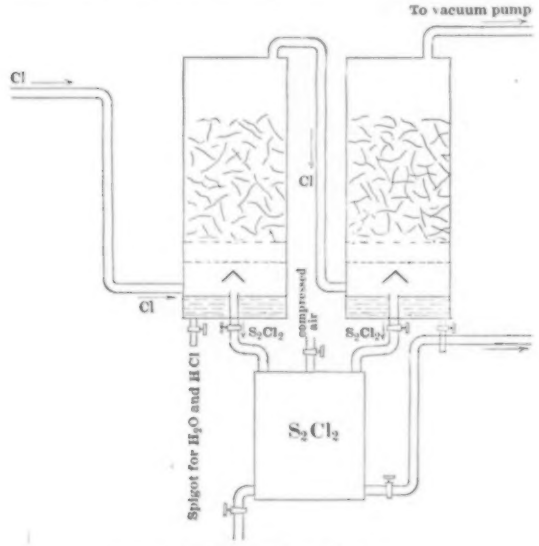


FIG. 2.—PRODUCTION OF S_2Cl_2.

If the chlorine gas is not absolutely dry, some hydrochloric acid is formed in time on the bottom of the sulphur containers; it is removed by means of small spigots in the bottom, without any loss of chloride of sulphur.

In the connecting tube between the sulphur containers and the vacuum pump, a box containing slaked slime is inserted for absorbing any chlorine passing out of the sulphur container so that the pumps should not be hurt.

For making SO_2Cl_2 the following process may be used. Sulphurous acid is brought together with chlorine in a vessel containing 50 gr. of camphor. In the beginning it is necessary to artificially heat the vessel, afterwards to cool it. The formed SO_2Cl_2 distills over at 77° C. from the camphor; at 45° some other compound distills over.

Chlorides of Phosphorus.

Phosphorus trichloride, PCl_3, and phosphorus pentachloride, PCl_5, may also be made advantageously from electrolytic chlorine. For making the trichloride, phosphorus is brought into an iron vessel, closed by a lid, as shown in Fig. 3. Through one opening in the lid, the chlorine gas is introduced, and through another opening the trichloride is led off. The latter is condensed in a water-cooled tube of copper and the liquid, which is clear like water, is collected in a stoneware vessel.

There is no necessity for artificial heating in this process. The reaction starts at ordinary temperature when the chlorine is introduced, and it is even preferable to cool with some water the vessel containing the phosphorus, since the heat of reaction is very large, and without this precaution some phosphorus may distill over.

From phosphorus trichloride it is easy to prepare pentachloride by passing more chlorine over the surface of the latter. The liquid solidifies after some time and becomes a yellow mass which represents the desired product.

In the dyestuff industries phosphorus oxychloride, $POCl_3$ is frequently used. It is obtained from pentachloride by gradually adding the proper quantity of water, according to the equation, $PCl_5 + H_2O = POCl_3 + 2HCl$. It is only necessary to take care that the addition of water is not made too

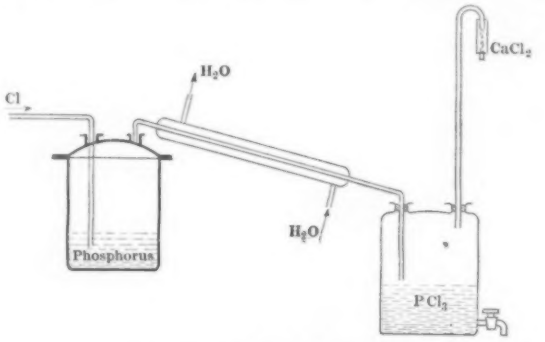


FIG. 3.—PRODUCTION OF PCl_3.

quickly, since this would result in an explosion. Finally, the escaping hydrochloric acid gas is condensed with water.

A very convenient method of making phosphorus oxychloride from pentachlorides is by means of distillation with dry orthoboric acid, according to the equation $2H_3BO_3 + 3PCl_5 = B_2O_3 + 3POCl_3 + 6HCl$. The reaction is absolutely quiet.

Peroxide of Lead.

Finely powdered lead acetate is put into a lead vessel, which can be heated with steam. Chloride of lime solution in the quantity theoretically necessary for the reaction, is then poured on it. The mixture is then heated to boil, until the vapor smells of acetic acid. The lead peroxide, thus formed, is placed on a filter and washed. 100 kg. of lead acetate give a 39 per cent paste (1 kg. paste containing 390 grams of PbO_2), this corresponds to an efficiency of 81 per cent of the theoretical one. Dyestuff manufactureres prefer this peroxide paste to PbO_2 anhydride.

Production of Organic Compounds.

Acetic Acid Anhydride.

The uses of electrolytic chlorine should, however, not be restricted to the production of inorganic compounds.

From phosphorus trichloride it is easy to make acetyl chloride, CH_3COCl, the method being described in text books. From acetyl chloride, in turn, it is possible to make acetic acid anhydride which is used in the dyestuff industries, as well as in the manufacture of vanillin, etc. Acetic acid anhydride is formed if 50 kg. of molten sodium acetate are gradually brought to reaction with 50 kg of acetyl chloride in a vessel which is well-cooled with water. By means of a vertical cooling apparatus provision is made to prevent acetyl chloride from escaping in such a way that the gas condenses in the vertical tube and flows back. This operation is to be followed by heating in a steam bath and distilling off the acetic acid anhydride.

Chloroform.

Chloroform is produced by mixing 250 kg. of 30° to 35° chloride of lime with 600 liters of water in a vessel of 2 cubic meters capacity, and adding slowly, with stirring, 20 kg. of acetone. A strong reaction takes place, and, without external heating, pure chloroform distills over. It may be shaken with concentrated sulphuric acid and may again be rectified. With the quantities mentioned above, one gets 32 kg. of chloroform, often somewhat more.

From chloroform it is possible to obtain tetrachlormethane (carbon tetrachloride) in a well-known manner.

Chloral.

Chloral hydrate is obtained by introducing chlorine into

alcohol; it is the well-known anæsthetic. On an industrial scale the manufacture if carried out as follows:

The starting material is 120 kg. of ethyl alcohol. The introduction of chlorine takes six days and takes place under the following conditions.

	Deg. Baume.	Temperature Deg. C.
First day	11	20
Second day	20	40
Third day	28	50
Fourth day	36	60
Fifth day	44	75
Sixth day	50	90

To get these temperatures, it is first necessary to apply artificial cooling and afterwards heating in a steam bath.

During the reaction with chlorine a number of combination products of alcohol with chlorine escape and are condensed.

Chloral, thus produced, is then treated as follows. 450 kg. are mixed with 550 kg. of sulphuric acid 66°, with following distillation. The distillate is again rectified and the material which first passes over (about 60 kg.) is separately collected and again distilled with the next quantity.

Production of Chloral Hydrate in Crusts.—Eighteen kg. of chloral anhydride are mixed in a glass vessel with 1800 grams of water; chalk is then added until the free hydrochloric acid is neutralized; now 50 grams of ammonia, 28 per cent, are added and the whole mass is distilled from a lead vessel in a calcium chloride bath. The distillate is shaken in glass bulbs until the mass is viscous; it is then poured on shallow dishes. In order to harden the crusts, the dishes are placed in a drying room which contains sulphuric acid in lead vessels. After twenty-four hours the crusts are ready; they are taken off and broken into pieces.

Production of Chloral Hydrate Crystals.—Twelve kg. of the distillate, as used for making crusts, are poured into 2 kg. of benzene, free from thiophene, and 50 grams of water are added to the mixture. The mixture is left alone at 20° C. Long needle crystals are formed. They dissolve again after a few days, and up to the tenth day the rhomboeder crystals will be formed in which for chloralhydrate is placed on the market. These crystals are allowed to drop off on a clay funnel and are dried over sulphuric acid.

DICHLORACETIC ACID.

Dichloracetic acid may be obtained in a simple way from chloralhydrate, as follows: 84 kg. of potassium ferro-cyanide are dissolved in 250 kg. of water, and to this solution 50 kg. of chloralhydrate are added, then boiled in a vessel provided with an inclined cooling tube, so that the liquid condensed in it flows back, while the HCN gas escapes and is condensed in a vessel containing KOH (10 to 20 per cent) to form KCN.

The reaction occurs according to the formula $3CCl_2COH + 3H_2O + 2K_4FeCy_6 = 3CHCl_2COOK + 3KCl + 2KFeCy_5 + 6HCN$. After three hours' boiling the solution is filtered. The mixture is evaporated and sulphuric acid is added to the solid residue, causing liberation of dichloracetic acid. $CHCl_2COOH$ is extracted with alcohol, then freed from alcohol and distilled and the brown distillate is rectified.

METHYLENE CHLORIDE.

Pure chloroform may also be obtained from chloral hydrate in a well-known manner. From chloroform, methylen chloride may then be made. For this purpose 50 kg. of chloroform (in an apparatus provided with an inclined tube, so that any liquid condensing in it flows back) are mixed with an excess of zinc, and hydrochloric acid is added. A vigorous reaction sets in. After three hours the content is distilled off. The distillate consists of methylene chloride, alcohol and unchanged chloroform. In a shaking apparatus water is added to the mixture and afterwards separation is then made. $CHCl_3$ and CH_2Cl_2 are separated as oil, dried with $CaCl_2$ and separated from each other by fractional distillation. Boiling point 41° to 42° C.

MONOCHLORACETIC ACID.

Monochloracetic acid, $CH_2ClCOOH$, is obtained by passing chlorine into concentrated acetic acid in presence of a catalytic agent, sulphur being suitable. During the introduction of chlorine the liquid is strongly heated on a sand bath. The end of the reaction is determined by measuring the increase of weight. After chlorine has been introduced for twenty hours, the mass generally solidifies, when cooled. Then follows fractional distillation. At 150° C. only a few drops pass over. What passes over at 150° to 190°, is cooled and the solidified portion is sucked off by means of a vacuum pump. The filtrate is again distilled and collected from 170° to 190°. The output from 100 kg. of concentrated acetic acid is 120 kg. of monochloracetic acid.

TRICHLORACETIC ACID.

Concentrated acetic acid is mixed with the theoretical amount of chlorine gas in sun light; this results directly in the formation of trichloracetic acid, CCl_3COOH.

ETYLENE CHLORIDE.

If etylene is brought to reaction with chlorine, etylene chloride $C_2H_4Cl_2$ is formed. It is purified by washing with dilute potassium hydroxide solution and dried over calcium chloride. This is followed by fractional distillation. The product is collected at 85° C.

MONOCHLORBENZENE.

To 150 kg. benzene C_6H_6 are added 2 kg. of iodine and chlorine gas is introduced with artificial cooling. For removing the iodine, dilute sodium hydroxide solution is used; this is followed by separation of the water layer and fractional distillation. First, the excess of benzene distills over, at 134° C. monochlorbenzene, C_6H_5Cl, while in the distilling apparatus higher chlorides remain back.

PARADICHLORBENZENE.

p-dichlorbenzene is made as follows: In presence of iodine, benzene is treated with chlorine until the increase in weight corresponds to the theory. The product may in turn be used for the preparation af p-dichlorbenzene.

PARADICHLORANILINE.

One hundred kg. of acetanilide are dissolved in 400 kg. of concentrated acetic acid and dry chlorine is introduced with continuous water-cooling until the increase in weight is 106 kg. When cooled, the mass solidifies. It is then filtered and washed with cold ethyl alcohol and dried. 140 kg. of dichloracetanilide are obtained. It is heated for several hours on a steam bath, in an apparatus provided with an inclined tube, so that any liquid condensing in the tube flows back. This is followed by fractional distillation. The compound is collected at 244° to 246° C.

BENZALCHLORIDE.

Benzal chloride, $C_6H_5CHCl_2$, is formed from toluole as follows: 100 kg. of toluole are heated on the steam bath in an apparatus provided with an inclined tube, so that any liquid condensing in the tube flows back. Chlorine is then introduced. First benzyl chloride, $C_6H_5CH_2Cl$, is formed, afterwards benzal chloride. With an excess of chlorine, benzotrichloride would be formed. Chlorine is introduced until the increase of weight is 75 kg. The product is then washed with a dilute alkaline hydroxide solution, dried, distilled and collected at 200° to 207° C.

METACHLORBENZALDEHYDE.

m-chlorbenzaldehyde is made as follows: 100 kg. of C_6H_5CHO are mixed with 300 kg. of concentrated sulphuric acid, 5 kg. of iodine are added and chlorine is passed through until the calculated increase of weight is 32 kg. The chlorination is completed within two days. The product, thus obtained, is diluted with water and is then left alone.

$C_6H_4 \begin{matrix} Cl \\ CHO \end{matrix}$ forms as oil; it is separated in a separating appa-

ratus, washed and shaken with bisulphite solution. The solution thus obtained is filtered off from some formed C_6H_5COOH and is decomposed with hydrochloric acid.

$C_6H_4 \begin{matrix} Cl \\ CHO \end{matrix}$ is formed as oil, which is separated and washed with water. This is followed by rectification. The distillate contains at 200° C. some water, iodine and unchanged benzaldehyde. The portion which distills over from 200° to 260° C., is separately collected.

It contains m. $C_6H_4 \begin{matrix} Cl \\ OH \end{matrix}$ and dichlorbenzaldehyde. The remaining product which smells strongly, probably consists of trichloraldehydes. The distillate of 20° to 260° C. is repeatedly rectified. m-chlorbenzaldehyde distills over from 210° to 215° C.

From m-chlorbenzaldehyde it is possible to make m-chlorbenzylidenaniline, by dissolution in alcohol and mixing with anilin dissolved in an equal volume of alcohol. Crystals are obtained which are again recrystallized from alcohol.

Conclusion.

In giving the above examples of both inorganic and organic compounds, which may be advantageously produced from electrolytic chlorine, I did not intend to give a complete review of all possible compounds. I have only given the most important ones which I have produced myself either on an industrial scale or on a smaller scale in the laboratory.

I hope I have shown that the use of electrolytic chlorine is not restricted to inorganic compounds, but that there is a large field of profitable applications in organic chemistry. It would appear probable that the electrochemical industries which have been built up at Niagara Falls, and which have so far been restricted to inorganic chemistry, may also become the center of industrial processes of organic chemistry. There is no reason why the United States should not manufacture, itself, the valuable organic products which are now exported, mostly from Germany, to the whole world, and in no small part to the United States, where products and dyestuffs are consumed in steadily increasing quantities.

SOME FIRST PRINCIPLES OF ELECTRICAL RESISTANCE FURNACES.

By F. A. J. FitzGerald.

In a paper[1] read by the writer at a meeting of the American Electrochemical Society, an attempt was made to present certain theoretical considerations in connection with electrical furnaces. As was brought out in the discussion that followed, the paper would have had its value greatly enhanced if actual values had been given instead of purely algebraical expressions. This cannot be denied, but it is a fact that those who use electrical furnaces are not disposed to publish data of this kind, preferring rather to wrap all details of practice in a cloak of secrecy. Nevertheless, a purely theoretical discussion of electric furnaces has its uses, for any one who has worked with them knows that by keeping certain first principles in mind much time may be saved in arriving at a successful result in his experiments. There seem to be valid reasons for believing that the first principles of electric furnaces are not a subject of general knowledge, for if they were, the existence of a number of astonishing patents on electric furnaces that have appeared within the last few years would be impossible. It would be invidious to illustrate this phenomenon by an actual example; however, a purely imaginary case may be cited:

Suppose that in a certain process an electric furnace was used and it was found that by increasing the temperature of the reaction the yield was greatly improved. This might be accomplished by increasing the resistance of the furnace without altering its dimensions in any way, and then using a current of the same amperage as before. In this way the rate at which heat energy would be developed in the furnace would be increased. It is a well-known fact that the heat energy developed by a current I passing through a resistance is equal to I^2R and *ceteris paribus* the temperature to which the resistance is raised by the passage of the current will vary with R. That physical fact is not patentable, nevertheless it is typical of certain patents that are taken out in connection with electrical furnaces; the ingenuity in such patents being found in the way the real principle is befogged by the judicious use of the obscure and cumbersome language characteristic of patent specifications.

In most of the earlier work with the electric furnace the arc was used, but in recent years the tendency in industrial work has been towards the use of the resistance furnace. There are two kinds of resistance furnaces:

(1) That in which the current is passed through a resistance, heating the latter to a high temperature, and the heat is then radiated or conducted to the material on which it is desired to work. Examples of the commercial application of this principle are found in the carborundum furnace, where the current passes through a granular carbon core, which in turn heats the surrounding charge of sand and coke; and in certain furnaces for the treatment of ores, such as those of Keller and Héroult, where the current in part, at least, passes through the slag.

(2) Furnaces in which the current passes through the material under treatment, as in Acheson's graphite furnace, and various furnaces for making calcium carbide.

In studying the principles of these furnaces, it is therefore necessary to consider both the phenomena of the generation of heat in a conductor by the passage of an electric current, and of the distribution of the heat that is generated.

* * * * *

When an electric current I, of electromotive force E passes through a resistance R, then, by Ohm's law:

$$(1) \qquad I = \frac{E}{R}$$

If W is watts, then the rate at which energy is given out in the resistance is:

$$(2) \qquad W = EI$$

or, expressing the equation in terms of R and I

$$(3) \qquad W = I^2R$$

Assuming that no other forms of energy are produced, heat alone is developed in the resistance, and the rate at which heat is produced is given by the equation

$$(4) \qquad C = JW$$

where C is calories and J is constant. Of the heat generated part is used in raising the temperature of the resistance and part is radiated into space, or, if the resistance is surrounded by some other material is conducted away. As the temperature rises the proportion of heat conducted away increases till finally a constant temperature is reached when the rate at which the heat is conducted away is equal to C as given by equation (4).

The rate at which heat flows from a hot body into a surrounding conducting material is a function of the difference of temperature between the hot body and the conducting material, the surface area of the hot body, and the heat conductivity of the surrounding material. If heat is being generated at a certain rate in the hot body, it follows from this that the temperature to which the hot body will rise is a function of the heat conductivity of the surrounding material, and the area of the hot body. Therefore, for a given material surrounding a resistance in which energy is given out at a definite rate, the temperature to which the resistance rises will vary directly as the surface area of the resistance.

Let it be assumed that a furnace of the Borchers type is

[1] Transactions of American Electrochemical Society, Vol. IV., p. 9.

used. This furnace is shown in longitudinal and transverse section in Fig. 1. A, A′ are large carbon blocks connected to a source of electric current, C is a resistance connecting A and A′, and M is the material which it is desired to heat to a certain temperature. It will first be necessary to determine the conditions under which that temperature is attained, and that will, of course, depend on the rate at which energy is given out in the resistance. Having found the proper rate, that is, the watts required, and knowing the surface area of C, the number of watts per square centimeter required for the object in view are known. If the resistance material C has a length L and a radius P, then for a given temperature and material to be heated we have the equation,

$$\frac{W}{2\pi PL} = a \qquad (5)$$

where a is the constant determined by experiment, and is given in watts per unit area.

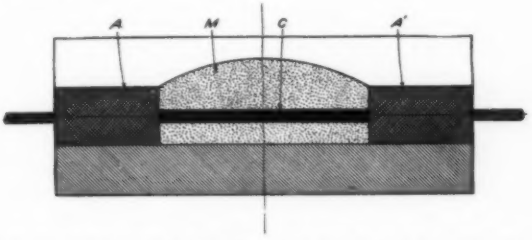


FIG. 1A.—LONGITUDINAL SECTION OF ELECTRIC FURNACE

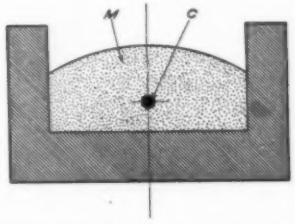


FIG. 1B.—CROSS-SECTION OF ELECTRIC FURNACE

Now let the resistivity[2] of C. be r' at the working temperature, then its resistance will be

$$R = \frac{r'L}{\pi P^2} \qquad (6)$$

If it is desired to use a current I with an e. m. f. E, then, since

$$R = \frac{E}{I}$$

equation (6) becomes

$$\frac{E}{I} = \frac{r'L}{\pi P^2} \qquad (7)$$

Equation (5) may be written

$$\frac{EI}{2\pi PL} = a \qquad (8)$$

From (7) and (8) the dimensions of the heating resistance for any furnace may be calculated.

On account of the variations in electrical resistance of materials with changes in temperature it is usually necessary to have some means of varying the voltage at the furnace terminals. This does not apply to furnaces where the material under treatment is constantly fed in and drawn off when finished, as in the case of certain resistance furnaces used for the reduction of ores. But in furnaces such as those used for the manufacture of carborundum and graphite, the change of resistance with temperature must be allowed for. In practice this is done by using some arrangement by which the voltage at the furnace terminals may be varied. In order that the furnace may be worked at full capacity from start to finish certain conditions must be fulfilled. In both the furnaces mentioned the resistance material through which the current passes is carbon, the electrical resistance of which decreases with increase of temperature. If, therefore, the resistance of the furnace at the beginning of the run is R_1, at the end of the run R_2, the maximum terminal voltage E_1, the minimum voltage E_2 and the total available power W watts, then the conditions for working the furnace at full capacity throughout the run are:

$$R_1 < \frac{E_1^2}{W} \qquad (9)$$

$$R_2 > \frac{E_2^2}{W} \qquad (10)$$

In many cases it is possible to so adjust the resistivity of the heating material that these conditions may readily be fulfilled. The importance of running the furnace at full capacity throughout the whole period of working is obvious. It frequently happens that where power is sold to the manufacturer he pays for his maximum consumption whether he uses it or not, so that any time spent in heating the furnace up to the point where its resistance is reduced so that it uses the maximum power for which it is built is so much loss. It will also appear that there is an important saving in heat losses where the furnace is heated as rapidly as possible.

These equations are useful in designing furnaces where it is necessary to obtain data from experimental furnaces of small size. For this purpose more simple forms of equations connecting the lengths and radii of the heating resistances in furnaces of different capacities may be derived. Equations (7) and (8) may be written,

$$PL = A\,E\,I \qquad (11)$$

$$\frac{L}{P^2} = B\frac{E}{I} \qquad (12)$$

where A and B are constants whose values are

$$A = \frac{PL}{EI} \qquad (13)$$

$$B = \frac{IL}{EP^2} \qquad (14)$$

If, now, it is required to build a furnace using a current I, at E volts, and the unknown length and radius of the heating resistance at L_1 and P_1, respectively, then we have from (13) and (14)

$$\frac{P_1L_1}{E_1I_1} = \frac{PL}{EI} \qquad (15)$$

$$\frac{I_1L_1}{E_1P_1^2} = \frac{IL}{EP^2} \qquad (16)$$

whence

$$P_1 = P\sqrt[3]{\frac{I^2}{I_1^2}} \qquad (17)$$

$$L_1 = L\frac{E_1}{E}\sqrt[3]{\frac{I_1}{I}} \qquad (18)$$

As an example of an application of these equations, an actual experiment may be quoted. The problem was to design a furnace having a capacity of 200 kilowatts, using a current of 4000 amperes at 50 volts. The temperature at the surface of the heating resistance had to have a particular value. Experiments were made on a small scale with the object of find-

[2] Resistivity is the resistance of unit volume of the substance in the form of a cube.

ing out the proper proportions. Details of the methods used in experiments of this sort must be reserved for another place; but the results showed that the desired conditions were obtained with a current of 200 amperes at 100 volts, and a heating resistance 365 cms. long and 10.2 cms. diameter. If these values are substituted in equations (17) and (18) it will be found that the proper length and radius of the heating resistance for the proposed furnace are respectively 495 cms. and 37.6 cms.

In general it will be found that in passing from a small furnace to a large furnace the heating surface of the resistance may be made larger than that calculated from the experimental work with the small furnace. This is due to the greater loss of heat that usually occurs in small furnaces, and will be better appreciated when the conditions governing the flow of heat in the furnace are considered.

Let it be assumed as before that the heating resistance is in the form of a cylinder of length L and radius P, and that it is surrounded with the material which it is desired to heat. The isothermal surfaces about the heating resistance are a series of cylinders coaxial with the heating resistance and the lines of flow of the heat form tubes of flow having the shape of wedges with their edges lying along the axis of the heating resistance. This is shown in Fig. 2, representing the

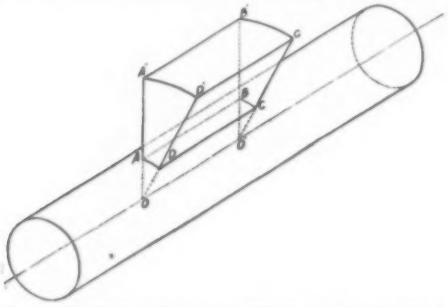


FIG. 2.—PROPAGATION OF HEAT IN RESISTANCE

heating resistance with radius OA equal to P. If any surface A B C D is taken on the heating resistance, and the radii OA, O'B, etc., produced to a cylinder representing one of the isothermal surfaces and having a radius P_1, there is obtained on the latter the surface A' B' C' D'. It will readily be seen that planes parallel to the axis of the cylinder will cut off from the wedge-shaped tubes of flow rectangles having widths proportional to their distances from the axis. Now, when a constant state is reached, so that the temperature of the heating resistance is θ_1 and that of the isothermal under consideration is θ_2, and if the heat conductivity of the material round the heating resistance is K, then the quantity of heat flowing per second is

$$(19) \qquad C = \frac{2\pi LK\,(\theta_1 - \theta_2)}{\log.\ \frac{P_1}{P}}$$

or if $P_1 - P = t$, and t is very small

$$(20) \qquad C = 2\pi LK\,(\theta_1 - \theta_2)\,\frac{P}{t}$$

From this is evident the importance of having the temperature of the heating resistance as high as possible. In general, the object in a furnace process is to convey heat rapidly from the source to the material to be heated. Herein lies one of the great advantages of electric furnaces, for it is possible to obtain very high temperatures in the source of heat. If it be assumed that the minimum temperature at which useful work is done is θ_2 and an isothermal surface where the temperature is θ_3, and having a radius P_2, is taken then the heat flowing from the isothermal θ_2 to θ_3 is

$$(21) \qquad c = \frac{2\pi LK\,(\theta_2 - \theta_3)}{\log.\ \frac{P_2}{P_1}}$$

or if $P_2 - P_1 = t_1$ and t_1 is small

$$(22) \qquad c = 2\pi LK\,(\theta_2 - \theta_3)\,\frac{P_1}{t_1}$$

Now it is evident that the efficiency of the process is given by the equation

$$(23) \qquad \text{Efficiency} = \frac{C - c}{C}$$

From equation (22) it is seen that as P_1, the radius of the isothermal of the limiting temperature is increased the efficiency diminishes. Furthermore, the greater the value of $\theta_1 - \theta_2$ compared with $\theta_2 - \theta_3$, the greater is the value of C compared with c, and hence the greater the efficiency of the process.

The great value in the use of electric furnaces for many processes lies in the high temperatures obtainable, thus permitting the attainment of a high efficiency that could not possibly be obtained where the source of heat has a relatively low temperature. An experiment illustrating this very clearly may be described.

A very intimate mixture of finely pulverized silica and carbon was made and packed in a graphite crucible. The latter was then placed in a Fletcher gas furnace heated with a blast lamp. Even after two hours strong heating no appreciable change was observed in the contents of the crucible. The crucible was then put back in the furnace and heated for about eight hours. Then it was found that a layer of a greenish colored substance was formed next the side of the crucible. The layer was only about 2 mm. thick. This greenish colored substance contained silicon carbide. As is well known this compound can be readily produced in the electric furnace. The enormous quantity of heat required for the production of a minute quantity in the gas furnace is due to the relatively low temperature of the burning gas. Nearly all the heat went to waste because the temperature was far too low.

In practice it frequently happens that the maximum temperature which may be used in the furnace is definitely fixed. Thus, in the manufacture of carborundum the temperature must not be allowed to go beyond that of the decomposition of carborundum. But from what has gone before it is evident that the temperature of the heating resistance should be carried as near to this point as possible. The temperature limit in the manufacture of "siloxicon" is much lower than that of carborundum, for if temperatures as high as that of the carborundum furnace are reached crystalline silicon carbide will be formed. It is evident that in all cases where careful temperature regulation is required, the importance of keeping in mind the principles on which the working of the furnace depends is very great.

The principles of those forms of resistance furnaces in which the current is passed through the material under treatment are somewhat more simple than those already discussed. Here a certain amount of heat must be supplied to a mass of material by the passage of the current.

Taking a simple case let a furnace similar to that shown in Fig. 1, but without the resistance material C connecting the terminals A and A' be assumed. The current flows between A and A' through the charge M, which it is desired to raise to a certain temperature. The rate at which heat is generated will be as given before by equation (4). To attain the desired temperature a certain amount of heat must be supplied, depending upon the mass of the material to be heated. Therefore to bring the mass up to the desired temperature in a certain time a definite number of watts per unit volume must be used. It is frequently the custom to speak of using a certain "current density" in furnaces of this kind, an objectionable

practice unless the electrical resistivity of the material through which the current passes is also given. Since the same material at different temperatures has different values for its electrical resistivity, the proper data to give in all cases are the watts per unit volume.

It has already been shown that the heat lost by radiation from the electric furnace previously considered is given by equation (22) and this also applies here. One of the important details to attend to then is keeping down the radiating surface of the furnace as much as possible. The furnace shown in Fig. 1 has the form of a parallelopiped, and it may readily be shown that the external surface is a minimum for a given volume when the parallelopiped is a cube. The form of a cube would therefore be ideal so far as the losses by heat radiation are concerned. There cannot be the slightest doubt that in actual practice there is not nearly sufficient attention paid to this point.

As the total amount of heat lost according to this equation will depend upon time, it is obvious that in discontinuous processes the temperature of the mass should be raised to the desired point as rapidly as possible.

Finally, in all electric furnaces the question of heat insulation is of immense importance, and is too often overlooked. On account of the very high temperatures used in electric furnace work, and the relatively great cost of the electrical method of generating heat, the necessity of efficient heat insulation is greater than in other processes. Efficient heat insulation is by no means a simple problem, but careful study of the subject is well worth while. In spite of the fact that good heat insulation may often seem to involve considerable cost, yet, when this cost is compared with that of the electrical power which, without it, will go to waste, its value will be quickly recognized.

The question of the efficiency of electric furnace processes is of great interest; but it is doubtful if any calculations as to absolute efficiency are of real value. The data at our disposal for making calculations are so uncertain that the results must be untrustworthy. We know little as to the specific heat of substances at high temperatures, but we are perfectly certain that so far as some of them are concerned the specific heats at high temperatures are quite different from those at low temperatures. In addition to this we only know at present within wide limits the actual temperatures attained. Where chemical reactions are involved we know nothing of the heat exchanges that take place at the high temperatures involved. Finally, in some processes, such, for example, as the production of graphite from amorphous carbon, we cannot form estimates of the heat absorbed in the vaporization of impurities in the carbon, which is nevertheless useful work. Again, in the manufacture of carborundum useful work is done by heating the mass crystals to a high temperature for a considerable length of time, thus obtaining the individual crystals large instead of in a fine needle-like form.

These considerations lead us to conclude that there is at present only one useful way of considering efficiency and that is, relatively. In all electric furnace work a careful account of the energy used should be kept and compared with the output. In this way the number of watts per unit of material produced can be obtained, and where a course of experiments on different furnaces or modifications of one furnace for a particular purpose are undertaken, it may readily be ascertained which form gives the most efficient results.

ARRIVAL OF FOREIGN ENGINEERS.—The first large party of foreign electrical engineers visiting this country to attend the St. Louis Congress, reached New York on August 24, when thirty members of the Associazione Elettrotecnica Italiana arrived on the Princess Irene, direct from Italy. A second Italian party landed on August 25 from the steamer Deutschland. They were met by Messrs. J. W. Lieb, Jr., T. C. Martin, C. W. Rice and C. de Muralt, of the American Institute of Electrical Engineers.

USES OF ACHESON GRAPHITE IN METALLURGICAL RESEARCH.

BY WOOLSEY MCA. JOHNSON.

In a paper read before the American Electrochemical Society in April, 1904 (ELECTROCHEMICAL INDUSTRY, vol. II., page 185, 1904), I described a new type of pyrometallurgical apparatus which was employed in our laboratory for measuring the "reduction temperatures" of the various ores of zinc. This apparatus was made of machined Acheson graphite. It showed such valuable properties for experimental work at high temperatures that we have made of it, contemporaneously with this work, other articles for this general class of work.

Acheson graphite possesses several marked advantages for the above-described purposes. Perhaps the chief of these is the fact that it can be machined on planer, lathe, drill-press, shaper, etc., to about 0.003 in. to any desired shape. This allows one to machine out accurately different parts of an apparatus which can then be assembled to a homogeneous whole. The joints can be either fitted or threaded. In many cases the bar can be machined directly to the proper form. Many articles can be made by hand by means of a sharp chisel or gouge.

The next valuable property of artificial graphite is its high capacity for conducting heat. With any sort of a decently designed experimental furnace, we can be reasonably sure that all parts of a solid graphite crucible are at nearly the same temperature. By drilling a ¼-inch hole in any convenient part of the crucible and inserting in it a pyrometer we have thus the true temperature (or nearly so) of the crucible and its contents. When a crucible of fire clay is used, we can be

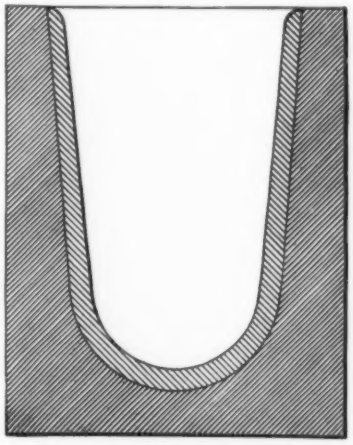


FIG. 1.—BRASQUED GRAPHITE CRUCIBLE MADE FROM 4-INCH ROUND ACHESON GRAPHITE BAR. (CUT ½ SIZE.)

quite sure that unless great care is taken, the charge is not heated uniformly. Especially true is this where the heat is applied locally by the electric current. Where many determinations are made the high thermal conductivity of electric furnace graphite is a great time saver and in a technical laboratory a large money saver.

The third good quality is that artificial graphite will stand without undergoing physical change a higher temperature than any other substance known to chemists. Below 2500° C. it has an extremely small vapor tension and neither melts or sublimes at even a much higher heat. Naturally it is always a reducing agent. By lining the apparatus with a suitable inert oxide, such as alumina, however, it can be employed in a wide range of work.

The fourth good quality of Acheson graphite is that it will stand sudden changes of heat without damage. I have on many occasions seized a red-hot graphite box with a pair of tongs and put it under a stream of water. On looking up I

found that those around had fled and were peeking at me around the corner of a furnace. The stream of water would blacken one side of the box, while the other side was still red. On taking it from beneath the stream the black side would redden in two or three seconds, showing how easily the graphite conducts heat.

I feel sure that one of two alternatives is true. Either

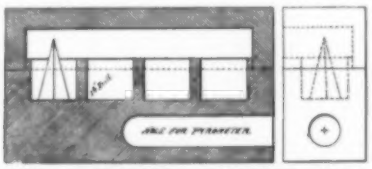


FIG. 2.—HOODED GRAPHITE APPARATUS FOR DETERMINING MELTING POINTS OF SLAGS AND METALS. (CUT ¼ SIZE.)

artificial graphite has almost no coefficient of expansion at high temperature, or, failing this, it has a toughness at high temperatures out of all proportion to its toughness at ordinary temperature.

Its great disadvantage is that when exposed to hot oxygen it slowly wastes away, consequently it should always be used in an atmosphere containing little oxygen.

Perhaps the most serviceable article that can be made out

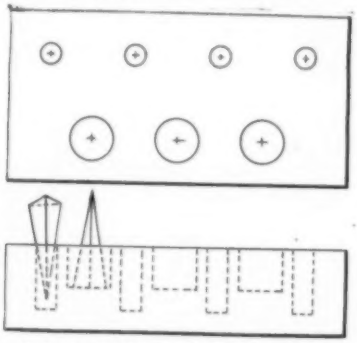


FIG. 3.—RACK FOR SEGER CONES. USED IN TEMPERATURE DETERMINATIONS IN ROASTING FURNACE. (CUT ½ SIZE.)

of graphite is a crucible. A crucible of any desired size from a half inch to 9 inches in diameter can be made by sawing off lengths of sound bars with hand saw and drilling out a cavity with a bit and brace. The walls should be from 3-16 inch to ½ inch thick. The work can be more conveniently done on a drill-press. Large sizes should be drilled on a lathe. The drillings are a fine powder and should be saved, as they can

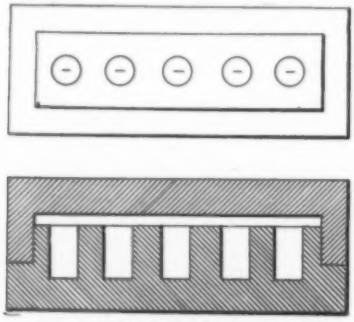


FIG. 4.—COVERED GRAPHITE BOX TO RECEIVE SEGER CONES. THIS BOX CAN BE INSERTED THROUGH MOUTH OF ZINC CONDENSER. (CUT ½ SIZE.)

be put to many uses. Tight-fitting covers also can be made on the lathe.

These crucibles can be brasqued as is an ordinary crucible. A good description of this operation will be found in Howes' "Metallurgical Laboratory Notes," page 115, *et seq.* We use often a dry paste of the brasquing material with water-glass (S. G. = 1.10). A brasqued crucible is shown in Fig. 1.

A tester, as shown in Fig. 4, on page 186 of the May issue of this journal, is useful for determining the boiling points of metals, reaction temperatures of solids. In case the indicator is a gas, a small tube is screwed in the hole. The apparatus is also useful in measuring the decomposition point of sulphates, etc.

Another handy piece of apparatus is that shown in cross-section in the adjoining Fig. 2 for determining the melting points of slags. This can be used at high temperatures above

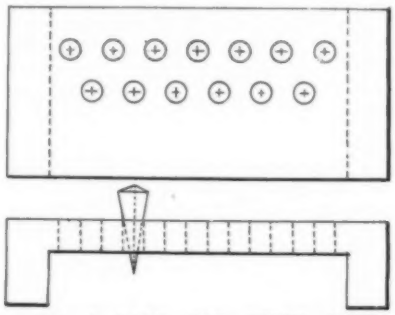


FIG. 5.—RACK FOR SEGER CONES. USED IN TEMPERATURE DETERMINATIONS IN ELECTRIC FURNACE. (CUT ¼ SIZE.)

1600° C., with fusible cones of known melting points as indicators. In this case it is possible to determine the melting points at extremely high temperature. An optical pyrometer could well be used in connection with this apparatus.

Figs. 3 and 4 show forms of apparatus that allow fairly accurate measurements by means of fusible Orton or Seger cones. Fig. 3 is the form I use daily in measuring the temperature of roasting furnaces of the Lanyon Zinc Co., at Iola. The cones are usually inverted, and as the graphite is bedded in the ore, it brings the "tester" quickly to the temperature of the ore. An apparatus of fire clay would delay the mechanically-operated rakes so long as to put daily measurements out of the question.

Fig. 4 is the form which I use in measuring the inside of a retort at the end of the shift. The box is made small with a tightly-fitting cover. It can be inserted on a small paddle through the mouth of a condenser on a zinc furnace.

These measurements can be made at a cost of 5 cents each, and do not require technical skill. A Le Chatelier pyrometer

FIG. 6.—CROSS SECTION OF BRASQUED ROASTING DISH. (CUT ¼ SIZE.)

is of use in the laboratory, but for the works it is too delicate. It is, moreover, extremely dangerous to put the couple inside a zinc retort.

Still another application is the brasqued roasting-dish of Fig. 6. This can be used where, in a test, an ore needs to be roasted at definite temperature.

Many possible future uses are in my mind, but most of the above have been given a thorough test. Enough has been said to show what a valuable material Acheson graphite is for factory and laboratory work.

It is a substance whose peculiar properties should be widely known. It is likely that when large sizes can be made Acheson graphite will have a wide use in large-scale, high-temperature work of the future.

WILLIAM H. NICHOLS.

During September the Society of Chemical Industry (London) will hold for the first time its annual general meeting in the United States, where a large number of its members reside. At this meeting Mr. William H. Nichols will succeed Prof. Ramsay as president of the Society, and for the second time in the history of the Society an American will be its president—the first to enjoy this honor having been Dr. Charles F. Chandler, of Columbia University.

While the latter represented chemical science in America, Dr. William H. Nichols was doubtless chosen from his connection with the chemical industries of this country. All will, we believe, agree that no one could be found more worthy to represent chemical enterprise in this country and at the same time represent that fine type of the plucky American captains of industry whose work has placed the United States industrially in the front rank of the nations.

William H. Nichols was born in Brooklyn, N. Y., on January 9, 1852. His father was George H. Nichols, and his mother Sarah E. Harris, both born in Providence, R. I., and of old New England stock. Mr. Nichols graduated from the Polytechnic Institute of Brooklyn in 1868, and from the New York University in 1870, with the degree of B. S. The same institution honored him with the degree of M. S. in 1873 for work done after graduation. In June, 1904, Lafayette College conferred on him the honorary degree of LL. D.

WM. H. NICHOLS.

What he has done for building up chemical industries in general in this country, is well illustrated by the fact that he founded and is president of the General Chemical Co., the largest producers of acids and heavy chemicals in this country. His progressiveness and pluck is indicated by his connection with electrochemistry since he founded and became president of the Nichols Chemical Co., now operating the largest copper refinery in the world. Mr. Nichols is a charter member of the American Chemical Society. He is also largely interested in mining and in the development of metallurgical properties.

Mr. Nichols has always shown a keen interest in education, and especially in technical education. He has delivered various lectures at Lafayette, and at request contributed memoranda to the Moseley Educational Committee, which visited this country from England some time ago.

Mr. Nichols' characteristic energy does not allow him, however, to confine himself to work in industrial chemistry and metallurgy. He has always manifested a strong leaning toward finance and banking. He is a director of some seventeen corporations in all, among them the Corn Exchange Bank, the Title Guarantee & Trust Company and the New York Glucose Company. Whenever Mr. Nichols assumes the duties of a director of a corporation, it means that he will take a very active part in its management. Thus, he is a member of the Executive Committees of the Corn Exchange Bank and of the Title Guarantee & Trust Company.

Mr. Nichols was the third president of the Brooklyn Young Republican Club, Hon. Seth Low being the first, and Horace E. Deming the second. Since the death of James W. Elwell, Mr. Nichols has been chairman of the Board of Trustees of the Clinton Avenue Congregational Church. For several years he has been president of the Congregational Church Extension Society of New York and Brooklyn. He is a member of numerous clubs, including the Chemists' Club, the Hamilton Club, Riding and Driving, Nassau Country Club, University Club of Brooklyn, Down Town Club of New York, Rembrandt Club, and various others.

Mr. Nichols has always manifested a keen interest in outdoor sports. He has a beautiful place upon the St. Lawrence River and is an enthusiast in yachting, fishing, shooting and golfing. This keeps him in good health and permits him to bear cheerfully the many burdens of his duties.

There is, however, one other characteristic which has assisted him greatly in his many enterprises. This is his sharp judgment of men. He has always been far-sighted and fortunate in the selection of his lieutenants, and to those chosen he gives absolute confidence. He is highly esteemed by his subordinates, while everybody who has to deal with him in business matters is impressed by the frankness and integrity of his character.

SULPHURIC ACID BY THE CONTACT PROCESS.

It is quite possible that the apparently clearer conception of the constitution of matter which is being given to the world at the present time, will shed more light on that mysterious chemical or possibly electrochemical property, catalysis. This power of causing radical changes in the composition of the surrounding medium with no detectable alteration in the catalyzer itself is possessed by a number of substances, particularly in a fine state of division. Finely divided platinum, however, presents the most conspicuous example of catalytic conversion.

Several explanations of this phenomenon have been suggested, but none of them has passed the hypothetical stage. The particular action with which we have to deal is one of simple oxidation, that of sulphurous anhydride to the sulphuric compound. It seems reasonable to suppose that this conversion has an intimate connection with the power of platinum sponge to occlude gases, notably oxygen (several hundred volumes being occluded at the ordinary temperature), but it is difficult to comprehend how a substance may oxidize for an indefinite time under constant conditions a surrounding gas, with the occlusion hypothesis only to work upon. Nevertheless, this platinum surely does.

Another theory is founded upon the power of platinum to remove from the space adjacent to it a great amount of sensible heat. There are several good reasons for believing that the compound formed by burning sulphur would be sulphur trioxide if the part played by the external conditions was nil. For instance, a very considerable amount of sulphuric anhydride is invariably found in ordinary "burner gas," and by carefully avoiding an undue rise of temperature in the kilns, the proportion of sulphuric anhydride can be greatly increased. Also, the heat of formation of sulphuric anhydride being in excess of that of sulphur dioxide is an indication in favor of the production of sulphuric anhydride when the reacting elements are allowed free play. But sulphuric anhydride is dissociated at a comparatively low temperature, (below 700° C.) and the heat evolved in its formation is great (22,000 Cal). In consequence, therefore, sulphur dioxide predominates in the gaseous mixture formed by the combustion of sulphur or pyrites. This predomination does not

obtain, however, after the burner gases, properly purified, have been passed through platinum-bearing material, and thus has arisen the assumption that the function of the platinum is to destroy the sensible heat, and to maintain the temperature below the decomposition point of sulphuric anhydride. Here, also, a limit to the catalytic power of platinum is indicated if the heat evolved is supposed to be simply conducted away, and it scarcely seems probable that if this heat energy were converted into thermo-electric energy, as has also been suggested, that such action would have escaped detection by one of the many investigators of the subject. Fortunately, however, our inability to follow the molecules' every move when in the neighborhood of finely divided platinum at the right temperature, does not prevent us from controlling its course through a comparatively simple apparatus, and with drawing therefrom a new and more valuable substance.

Sir Humphrey Davy first observed the catalytic action of platinum in 1818. But for a period of over fifty years thereafter, no practical results were achieved, though many proposals were at intervals published. Notably, Phillips, of Bristol, England, patented in 1830 a process for manufacturing sulphuric anhydride by catalysis.

The researches of Winkler, published in 1875, combined with an increased demand for the fuming acids, are no doubt responsible for the position of the industry to-day.

Winkler was chiefly engaged with the production of the so-called Nordhausen Oil of Vitriol from copperas, and finally from weaker sulphuric acid itself. By the decomposition of these substances the sulphur dioxide and oxygen were obtained in stoichometrical quantities, a condition Winkler believed necessary for profitable operation.

The obvious object of these many years' work was the production of sulphuric acid from burner gases, and it was left for Dr. Rudolf Knietsch, of the Badische Anilin and Soda Fabrik to accomplish the result on a profitable commercial scale.

It is presupposed that every one is familiar with the production of sulphur dioxide either from pyrites or brimstone, therefore a description of the kiln department of an anhydride plant will be omitted.

Experience has shown that the most economical procedure in operating either a contact or chamber sulphuric acid plant, considering both roasting and acid proper departments, is to produce gas of the following composition: Sulphur dioxide 7 per cent, oxygen 10 per cent, and nitrogen 83 per cent. Therefore the roasting of the brimstone or pyrites needs no particular discussion in the consideration of the contact method.

As soon, however, as the gas has left the kiln room, radical departures from the older practice are encountered. In fact the procedure is exactly reversed. In the chamber process, including stills and arsenic purification plants, the acid is made containing the impurities, arsenic, antimony, silenium, tellurium, iron, nitrogen compounds, etc., these substances being eliminated, subsequent to the withdrawal of the acid from the chambers. But the contact process necessitates an actual chemical elimination of everything except sulphur dioxide, oxygen and nitrogen before the gas is admitted to the contact compartments. The experience of every manufacturer who has installed a contact plant will bear testimony to the truth of this statement. The difficulty of effecting the purification was for a considerable time apparently insurmountable, it yielding only to indefatigable efforts combined with elaborate and expensive experiments.

Arsenic, which shares in the metallurgical world the odium that "basic salts" enjoy in a laboratory, was found to be the prime trouble-maker, chiefly because under the existing conditions it acts with great versatility in its chemical attachments and is most evasive in whatever role it elects to act.

In the first place, arsenical fume has been recognized for years as an exceedingly difficult substance to deposit from gases, and this is naturally present in the combustion products of arsenical pyrites. Unfortunately, most pyrites are arsenical.

Secondly, arsenious oxide, sulphuric acid and iron flues form a combination suitable for the production of arseniurretted hydrogen. The sulphuric acid must therefore be prevented from condensing in iron flues. It has also been found advantageous to cool the gas gradually, condensation being less easily effected with rapid extration of heat. Another phase in which arsenic appeared as a source of annoyance was in its tendency to accompany, persistently, extremely minute particles of sublimed sulphur.

A supplementary oxidation of the gases was therefore necessary to break the union between the arsenic and sulphur. This has been most effectually accomplished by the introduction of a jet of steam, causing at the same time a perfect homogeneity of the gas.

The mechanical impurities carried along by the current of gas, such as iron oxide and zinc oxide frequently met with, can be isolated byordinary dust chambers and scrubbing towers.

As has been previously noted, the heat of formation of sulphuric anhydride is great, and thus arises at once a most interesting and important feature of the contact process.

Also, before the reaction expressed by the equation $SO_2 + O = SO_3 + 22{,}000$ Cal., takes place quantitatively, the reacting gases must be raised to a temperature of at least 375° C. The limits within which the reaction takes place are wider than was for a time generally believed, but it is true that the heat developed by the combination will greatly reduce the yield of sulphuric anhydride if not removed.

The two facts, that a large number of heat units are generated, and that they have a disastrous effect on the completeness of the conversion, has given rise to, as termed by Knietsch, "regenerating cooling." That is, the heat extracted from the platinum mass in operation is used to heat the gases approaching the contact chamber to the required initial temperature, or, expressed differently, the cool ingoing gases are employed to check the rise of temperature above the decomposition point of sulphuric anhydride. Thereby is effected an economy in platinum space and fuel.

The first sucessful application of this principle was that of R. Knietsch, assignor to the Badische Anilin and Soda Fabrik of Ludwigshafen, Germany (U. S. Patent 688,020). Other inventors have subsequently employed the thermo-chemical effects of the reaction with a similar result, but their method of procedure has of necessity differed materially from that of Knietsch. The plants operating under the patents of Knietsch, Max Schroeder (controlled in the U. S. by the New Jersey Zinc Co., U. S. Patent 742,502) and Herreshoff (controlled by the General Chemical Co., U. S. Patents 719,332 and 719,333) produce by far the greater amount of acid made by the contact method. It will therefore be interesting to note briefly how in these three cases infringement has been obviated in the matter of "regenerating cooling."

Knietsch's apparatus consists in a well-insulated vessel of iron or masonry provided with "ingress and egress" passages, arranged, however, so that within the space there are counter currents of gas. The comparatively cool sulphurous acid from the purifying apparatus traveling upward, completely surrounding a number of iron tubes containing the active substances through which the ascending current is forced to pass in the opposite direction before leaving the apparatus. Provision is also made for introducing the sulphurous acid at the center and top of the chamber, thus permitting a more perfect regulation of temperature without varying the quantity of gas operated upon.

Schroeder brings the purified sulphur gas to the required temperature by passing it through conduits placed in the kilns or by means of a heat transferrer adjacent to the kilns, thus employing the heat of burning pyrites or sulphur instead of that developed by the oxidation of sulphur dioxide.

Herreshoff makes use of the heat liberated in the contact chambers, but his method differs from that of Knietsch in that

he effects a transfer of heat in a separate specially constructed apparatus external to the contact mass. Therefore, the gas before entering the converting pots, of which there are two, travels through two separate vessels simultaneously and in close proximity to a counter current of the highly heated sulphuric anhydride leaving the contact pots.

It may thus be seen that the temperature of the platinized material is not subject to control from overheating, except by varying the amount of sulphur dioxide differing in this respect from the practice of Knietsch.

It is probably for this reason that W. C. Ferguson, also assignor to the General Chemical Co., subsequently patented an apparatus consisting of a "plurality of contact chambers," of such dimensions that the sulphur dioxide is not wholly oxidized in the first one, and he further provides means for introducing a regulable supply of oxygen or air into the stream of gas passing from one contact pot to the next. (U. S. Patent 723,595).

This method of operation permits of a more simply constructed contact vessel than that employed by Knietsch. This would, however, appear to be of little moment, as the method necessitates the heat transferring apparatus which are built on the same principle as Knietsch's converters.

Instead of disposing the platinized asbestos in tubes Herreshoff places it evenly on perforated plates arranged one above the other about an inch apart, the current of gas naturally being down.

In all of the methods referred to between 95 per cent and 100 per cent of the sulphur dioxide has undergone conversion to sulphur trioxide and is thus ready to be absorbed to produce acid of the desired strength, rarely under 98 per cent, with the actual solid anhydride for the maximum limit.

It is a surprising fact that water, even under conditions of most intimate contact, fails to unite, except to a slight degree, with the sulphuric anhydride contained in the gases issuing from the converter, or more properly from the cooler, as it is, of course, necessary to reduce the temperature of the stream before passing the gases into the absorbing device.

It might be remarked as a matter of general interest that a solution of barium hydrate, and even of caustic soda, allows the sulphuric anhydride to bubble through them with only slight absorption.

In the presence of a large amount of sulphuric acid, however, the anhydride is completely hydrated. Thus it comes about that strong sulphuric acid, 96 per cent and over, is generally used as the absorbing agent.

The acid in the absorbers, usually two or three in number, is kept at practically constant strength by the addition of water or, better still, chamber acid, if available, the supply being regulated by the amount of strong acid withdrawn from the apparatus and the amount of sulphuric anhydride introduced.

A word in regard to the various contact materials. It has been found that the greater the surface of active substance exposed, the more perfect is the reaction. In this particular, platinized asbestos fulfills the requirements better than anything else. This is prepared by treating a highly silicious fibre with platinum chloride solution, together with a reducing agent, oxalic acid, for instance, and heating the mass so prepared to drive off hydrochloric acid, and other volatile matter, leaving only the platinum deposited on the asbestos in a very fine state of division. In case of contamination, it is not a simple matter to recover the platinum entirely by working over the platinized asbestos. Schroeder therefore has patented the use of a soluble salt as a carrier for platinum, such as "soluble salts of the alkalies of the alkaline earths" (U. S. patent 636,925). To recover the platinum it is obviously only necessary to dissolve the soluble matter with water.

Other catalytic agents that have been proposed are freshly prepared ferric oxide made by roasting pyrites, anhydrous copper sulphate, copper oxide and chromic oxide.

It is a much disputed point whether the contact process will in time become a competitor with the lead chambers for the production of acid below 60° Be'.

On the authority of one of the most successful users of the contact process abroad, chambers are inevitably doomed in localities where the conditions are reasonably favorable for contact operation. Such conditions would probably be moderate priced fuel and a fair demand for the higher grades of acid.

The recent improvement effected in the chamber process is a remarkable instance of response to threatened competition by an old-established and most conservative industry. A few years back 20 cu. ft. of chamber space and 0.025 pounds of niter per pound sulphur burned was considered fair practice. At the present time, in up-to-date plants these figures must be changed to 10 or 12 cu. ft. and 0.015 pound niter. Improved construction of the towers, the use of fans to insure uniformity of operation regardless of atmospheric conditions, and to thoroughly mix the gases, and running nitric acid down the Glover tower, instead of "potting" niter, have been the chief contributors to this result.

In the concentrating department Kessler stills have brought down the cost of producing 66° Be' and 66½° Be' acid.

In regard to first cost, a chamber plant is probably somewhat less expensive to erect, but occupies many times the space required by a contact plant, and entails a very much greater repair bill.

If, however, stills be included there is no doubt a handsome balance in favor of the new process.

Some idea of the magnitude of the sulphuric acid industry can be obtained from the following figures taken from the census report of 1900:

No. of establishments (all Chamber) 127
50° acid produced, 1,906,878,903 pounds.
60° acid produced, 34,023,131 pounds.
66° acid produced, 754,558,455 pounds.
Brimstone burned, 53,997,752 pounds.
Pyrites burned, 673,076,695 pounds.
Value acid, $14,247,185.

THE MANUFACTURE OF FERRO-ALLOYS IN THE ELECTRIC FURNACE.

By GEORGE P. SCHOLL, PH. D.

Only such ferro-alloys as are manufactured on an industrial scale in practice will be dealt with in this article. Alloys which have been made on a laboratory scale, and for scientific purposes only, will, therefore, not be considered. As the manufacture of the first named class of alloys has within recent years, and especially in Europe, assumed quite large proportions, a brief review of the subject will not be without interest.

That the ferro-alloys are of the greatest importance as well to the metallurgist as to the practical mechanic is such a self-evident truth that it hardly needs restatement. To the latter it is brought home very forcibly by the practical revolution of the old methods of running machine tools through the introduction of the modern high-speed tool steels in the manufacture of which ferro-alloys obtained in the electric furnace play a prominent part. And the end is not yet. With reference to this point it may be permitted to quote the closing remarks of Mr. W. Metcalf, in a paper on alloy steels, read at the June meeting of the American Society for Testing Materials, "The making and using of steel containing practically only carbon and iron, with some modifications made by the use of small quantities of manganese, silicon, tungsten and nickel have occupied the best minds in the manufacturing and engineering world for many years. At the close of the century it was customary to "point with pride" and to assume that so much had been done and so much was known, that there was no room for more revolutionary changes, and that the coming generation had only to tag along, utilizing these

great advances with ease and comfort to themselves, and with blessings upon their predecessors. Now, in the first five years of the twentieth century, we older men find ourselves standing on our heads once more. A revolution has come already, and we can look forward to a splendid opening for the best energy and thought of the succeeding generation."

The problem of the application of the electric furnace to the manufacture of the various ferro-alloys has received considerable attention in Europe, especially in France. The principal stimulus to research in that direction was given by the crisis which occurred in the calcium carbide industry several years ago, on account of the enormous overproduction of this article. As many more factories had been built than were required to furnish the world's supply, the managers of the carbide works found themselves compelled to find other things which could be manufactured in their carbide furnaces. The latter could be directly applied to the manufacture of ferro-chromium and ferro-silicon, and products could be obtained, which, crude as they were considered from the standpoint of latter day purity, could at least compare favorably with the products of the blast furnace or the crucible. Gradually, however, an evolution took place, as the demand for purer materials on the part of the steel makers became greater, and at the present time alloys of a purity, especially in regard to carbon, unknown a few years ago, can readily be obtained in the market. Ferro-chromium furnishes a good illustration in this respect. The first ferro-chromium alloys manufactured in the electric furnace, adapted as it was from the manufacture of calcium carbide, contained from 7 to 9 per cent of carbon. As it was not very difficult to make such alloys in the electric furnace, an over-production was soon apparent, and prices went to smash. A tendency to cut down the percentage of carbon, however, gradually manifested itself, and processes were devised to accomplish this, so that at present, according to Dujardin, the engineer in charge of the sales office of the Comptoir International du Ferro Silicium, in Düsseldorf, Germany, there is no demand whatever in Germany for the ferro-chromium containing above 5 or 6 per cent of carbon, the alloys most in demand being those that contain between 4 and 5 per cent of carbon. The products furnished by the Société La Néo-Métallurgie in Rochefort sur Mayenne, one of which contains 0.5 per cent, and the other 2 per cent of carbon, are much appreciated. That an article with such a low percentage of carbon is much higher priced than the ordinary, goes without saying.

The industrial application of the electric furnace to the manufacture of the ferro-alloys has been somewhat lagging behind in this country, though there are some notable exceptions in the case of the Willson Aluminium Company, and the well-known and indefatigable investigator, A. J. Rossi, who has paid particular attention to the problems for a number of years, and especially to the manufacture of ferro-titanium. The causes for this apparent lack of interest are varied. In the first instance, the stimulus due to the crisis in the carbide industry was lacking, as there was no over-production of carbide in this country, owing to the consolidation of the various carbide works. In the second place, the price for hydro-electric power is much less in Europe, and especially in France, than it is in this country.

Albert Keller, of Keller, Leleux & Co., the well-known French electro-metallurgist, in a paper read before the June, 1903, meeting of the British Iron and Steel Institute, estimated the cost of an electric kilowatt year as 50 francs ($9.70). The price charged at Niagara Falls is more than double that amount. If the assertion of Simpson (Electrochemical Industry, Vol. 1, page 278), that under favorable conditions electric power can be produced for less than $4 per electric horsepower year, can be realized, conditions would be different.

That manufacturers in this country find it hard to compete under these circumstances against the foreign manufacturers, who have the advantage over them in cheaper power and labor, is pretty evident. In addition to this, the ferro-alloys of whatever description coming into this country only pay a duty of $4 per ton, as they are being classed by the Custom House officials as similar to ferro-manganese and not specially provided for in the tariff act. A case in which this question is involved is at present being taken before the Supreme Court of the United States. It involves the four products ferro-chromium, ferro-tungsten, ferro-molybdenum and ferro-vanadium, the duty on which had been assessed at 20 per cent ad valorem, as unwrought metals. The importers appealed from this decision to the Board of General Appraisers, which reversed the local appraiser and decided upon the duty of $4 per ton. The case was appealed to the United States Circuit Court, which has quite recently given its decision upholding that of the Board of General Appraisers. The Treasury Department has, in view of the importance of the case, decided to carry the matter before the Supreme Court. It is pointed out by the Willson Aluminium Company, who have co-operated with the Treasury officials in this litigation, that ferro-chromium is taxed by similitude with ferro-silicon, ferro-manganese, etc., at $4 per ton, though the price of the two former varies from $28 in the first to $50 per ton in the second case, while ferro-chrome is worth at least $250 per ton. The final settlement of this case will be of great interest.

The furnaces used for manufacturing the ferro-alloys are of various types. In the beginning they were simply adaptations of the ordinary carbide furnaces, with slight modifications. Gradually, however, their construction became more adapted to the needs of the product. One of the prime considerations was the production of pure materials, especially as regards the amount of carbon which they contain. This led to the devising of furnaces with the object of eliminating as much as possible the danger of contamination by the electrodes, by keeping the material under treatment out of contact with them. Further efforts were directed towards increasing the efficiency of the furnaces and minimizing the losses from the radation of heat. Considerable improvements have also been made in the contrivances designed to effect the regulation and control of the electrodes and to facilitate their removal and replacement. Much improvement has also been made in reducing the losses by volatilization by paying proper regard to the requisite current density and temperature.

The principal aim in these furnaces has been to reach temperatures which lie between that of the ordinary metallurgical melting furnace and that produced by the electric arc.

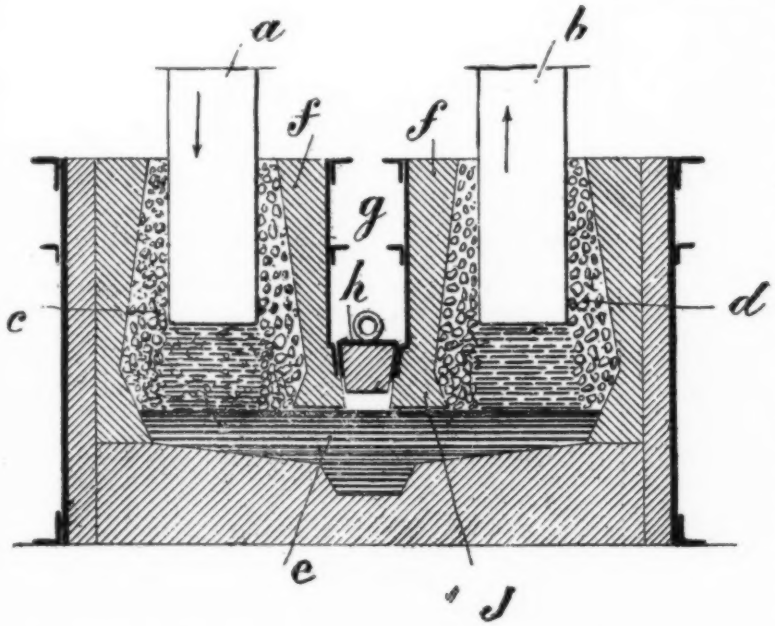
Considerations, such as outlined above, led Héroult, the well-known French electrometallurgist, to the construction of a furnace, in which two separate arcs in series are used, which play through an insulating layer of slag between the fused conducting material on one hand and the two electrodes on the other hand. A shunt circuit between each of the electrodes and the fused material includes two voltmeters, the indications of which serve to constantly verify and regulate the positions of the electrodes and to indicate whether the furnace is working properly or not. Furnace constructions by Héroult adapted for the manufacture of ferro-alloys have been described in Electrochemical Industry by Héroult himself, as well as by the writer in his monthly analysis of current electrochemical patents. (See Electrochemical Industry, Vol. 1, pages 449, 63, 287, 467).

Constructions by Albert Keller, of Keller, Leleux & Co., Kerousse, France, which bear a certain likeness to the constructions of Héroult, are described in Electrochemical Industry, Vol. 1, page 163. A construction by the same inventor, recently patented in France, to be used for the manufacture of metals and their alloys, is shown in cross-section in the accompanying illustration. It has two electrodes, *a* and *b*, which are placed in separate compartments, *c* and *d*, formed

by the interposition of a construction, *f*, of refractory material.

A plug, *h*, accessible through space, *g*, allows communication with the interior of the furnace, either for the introduction of additions or the taking of samples. The fused alloy, *e*, accumulates on the bottom. The advantage claimed for this construction is the prevention of secondary actions between the electrodes, such as occur when they are both plunged adjacent to each other into the material under treatment. The electrodes are of different polarity, and two or more of them per pole can of course be employed.

Another principle is made use of by Girod, the manager of the Albertville works. His furnace was illustrated in a paper by Mr. P. McN. Bennie, in the August issue of ELECTROCHEMICAL INDUSTRY, page 309.



It is claimed that the temperature can be regulated at will; it may be maintained at less than 500° C., and go as far as 3500° to 4000° C. Ferro-tungsten of 85 per cent is stated to have been produced in this furnace. The Usine Electro-Metallurgique Albertville produces ferro-molybdenum, ferro-chromium, ferro-tungsten, ferro-vanadium, etc.

A different method for the manufacture of the ferro alloys in the electric furnace has lately been described by A. J. Rossi in ELECTROCHEMICAL INDUSTRY, Vol. I., page 523. It consists briefly in charging metallic aluminium in waffles, ingots, scrap or the like into an electric furnace and melting it by the current. The metallic oxide to be reduced is then introduced, when the aluminium oxidizes with incandescence, the furnace becoming glowing white. The current is then reduced considerably or stopped entirely until the intensity of the reaction is over, and it is then turned on again to keep the product in a molten state for some time longer, when they can be freed from any aluminium left in them by the addition of small quantities of the original oxide used. He claims some advantage over the Goldschmidt process of reduction in a crucible by powdered aluminium as used by the Allgemeine Thermit Gesellschaft, Essen, Germany, which also manufactures various ferro-alloys. The latter process has been described at length in ELECTROCHEMICAL INDUSTRY by Dr. Goldschmidt himself as well as by the writer. (ELECTROCHEMICAL INDUSTRY, Vol. I., pages 527 and 175.)

FERRO-SILICON.

This alloy has been one of the first to be manufactured on a commercial scale in the electric furnace, and its production at the present day has assumed quite large proportions. In Europe, according to Pitaval, in a paper read before the French Société de l'Est (Journ. de l'Electrolyse, Vol. 13, page 3), ferro-alloys, rich in silicon, are made in the following establishments: Compagnie Generale d'Electrochimie, Bozel, Savoy; La Volta Lyonnaise, Moutiers, Savoy; Griesheim Electron Gesellschaft, Griesheim, Baden; Allegemeine Carbidwerke Actiengesellschaft, Mattrei, Austria; Kellner, Partington Pulp Company, Shapsborg, Norway, which form one sales group. Another group comprises the Bosnische Electricitaets Gesellschaft, Jajce, Bosnia; the Schuckert Society at Meran, Tyrol; the Société des Usines Electriques de la Lonza, at Plan du Var, France, and at Gampel, Switzerland; the Lechbruch works at Lechbruch, Bavaria and the works of the Schuckert Society at Hafslund, Norway. These eleven works have constituted a selling syndicate in Paris. The independent concerns are: The Société Electrométallurgique Francaise, at La Praz, Savoy; the Usine du Giffre, a part of whose power is rented to the Société La Néo-Métallurgie; the Compagnie Electrothermique Keller, Leleux & Co., at Livet; the Société des Carbures Métalliques at Notre Dame de Briancon and the Société des Usines Electriques de Hagneck, at Bienne, Switzerland. The above works, however, do not devote themselves exclusively to the production of ferro-silicon.

The methods applicable to the production of ferro-silicon are different. It can be prepared as in the blast furnace by the reduction of iron ores and siliceous materials, or what amounts to the same thing, by the reduction of low grade iron ores, containing a large amount of silica, and which would ordinarily be of very little value for the blast furnace process. Gin (see ELECTROCHEMICAL INDUSTRY, Vol. I., page 131) has proposed metalliferous slags from the acid Bessemer or Siemens-Martin furnace, which he proposes to treat with a current at 25 to 30 volts, the "power density" (the number of volts per square centimeter of the perpendicular cross-section of the electrode) not to exceed 70 volts in order to avoid losses through excessive volatilization.

A second method consists in the reduction of silica by carbon, and its immediate absorption by metallic iron, which is added as such. The iron in this case does not play any role in the reduction, but simply serves as collector and retainer for the silicon. As stated by Jouve (Journ. de l'Electrolyse, August 1, 1902), the silicon is more volatile than the iron under these conditions, and moreover, it has a specific gravity quite close to that of the mixture of carbon and silica, which is in a half molten and very viscous condition. An emulsion of silicon is, therefore, formed in the mass, as the silicon is produced in very fine particles. It therefore has a tendency to remain in the mass and not to flow down to the bottom of the furnace. It is seized upon by the molten iron and the alloy collects on the bottom.

(To be continued.)

The Congress of Arts and Science will be held in St. Louis from September 19 to 25. The idea of this congress grew out of the thought that the sub-division and multiplication of specialties has reached a stage at which it would be desirable to bring the scattered sciences into mutual relations. Section X. is devoted to Chemistry.

THE ELECTRICAL PROPERTIES OF THE FILMS THAT FORM ON ALUMINIUM ANODES.

By William Roy Mott.

The insulating films that form on aluminium anodes will be considered in this paper as regards their specific resistance, insulating strength, and specific inductive capacity. These properties can be calculated with the data given in a previous paper[1] on the dimensions of the film. The thinness of the insulating layer gives us a condenser of large capacity; and since as anode, the insulating effect is very great, and as cathode almost nil, thus we obtain with an aluminium electrode an excellent check value, permitting current to flow in only one direction. These two well-known electrical devices, the aluminium electrolytic condenser and rectifier, are of great potential, engineering importance, and so it is hoped that the considerations presented here may aid in the practical work, as well as in the theoretical development. From a theoretical standpoint, much interest attaches to the exact *modus operandi* of the aluminium anode process. An open question[2] of long standing, both with regard to the electric arc and the aluminium anode is "Does the polarizing effect depend upon a high resistance or a counter electro-motive force?"

Since Streintz's time (1887) the prevailing view has been that the effect is due to a dielectric polarization of a thin film of great resistance. But Cook has recently argued in favor of a true counter electromotive force, as against the resistance idea. His argument and work consist in showing that the discharge potential of aluminium electrodes is nearly equal to the impressed voltage, and so he concludes that the difference between these voltages is used up in C R drop. Cook measured by Kohlrausch's method the resistance of two aluminium electrodes immersed in an alum solution and found it to be low. But how can one get reliable results on conductivity with Kohlrausch's apparatus in the presence of large capacity current? So likewise the other work does not prove the presence of a counter electromotive force such as would be observed in a circuit containing a motor or storage battery. A condenser in parallel with a high resistance would produce the effect observed, *i. e.*, high discharge potentials.

Such an arrangement is shown in Fig. 1, where the condenser (C) and the resistance (R) are in parallel. If a steady pressure is put across *a* and *b*, then a steady current will flow that can be calculated from Ohm's law. The dielectric polarization on C can have no effect on the steady current in R. Now, breaking the circuit and reading the discharge potential, it should be nearly equal to the impressed pressure. Similar effects may be obtained with other arrangements where no real counter electromotive force affects the flow of a steady current. For example, apparatus containing self-induction should not be used in circuits where discharge potentials are being read. These facts make it plain that the postulation of a true counter electromotive force is not always necessary in an electrical circuit giving high discharge potentials. In the present case the resistance (R) and capacity (C) are merged together into one apparatus called the aluminium electrolytic condenser.

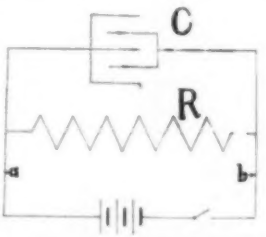


FIG. 1.—ARRANGEMENT OF EXPERIMENT.

The question has been asked as to a condenser with an imperfect insulator for dielectric, "Is the steady current that flows affected by the dielectric polarization?" Most physicists answer this question in the negative. For example, Klemencic[3] in working with the mica condenser calculates the specific resistance of mica (silicate of aluminium) as 6×10^{15} ohms per cubic centimeter from the leakage current of the condenser. One more objection to Cook's view is that it involves a startling exception to Ohm's law. Does a film subjected to dielectric stress change its resistance?

In view of these facts showing the difference between dielectric polarization and ordinary electrolytic polarization, the author of this paper believes that the best explanation of the behavior of the aluminium anode is found in a film of *great resistance* and not in a counter electromotive force similar to that obtained in an electrical circuit charging storage batteries, etc. After a brief reference to the early work upon the aluminium anode, this idea of high resistance will be considered in fullest detail.

Asymmetric, insulating effects have been studied for a long time. Before the separation of metallic aluminium by Wöhler in 1826, asymmetrical resistance had been observed and classified by Erman in 1806. He found that dried soap acts as an asymmetrical resistance. Later, in Faraday's time, the passive state of metals was extensively investigated, but aluminium was not included in this work. When massive aluminium became generally available, tests were made on its use in a primary battery and its position in the electrochemical series. Prominent workers in this direction were Poggendorff, Wheatstone, Heeren and Karmarsch, and Hulot. Buff (1857) followed up this line of work and discovered the insulating effect of an aluminium anode. Independently, Planté[4] (1859) discovered the same effect. Planté says: "If the oxide is insoluble and a bad conductor, then the current is almost entirely stopped. This is what one observes very plainly with aluminium in acidulated water." The work begun by Wheatstone, Buff, Planté, Tait and Ducretet was continued by Beetz, Cail, Slouguinoff, Neyreneuf, Streintz, and some hundred other workers. References will be made to these as occasion arises. The consideration of the specific resistance of the film that forms on aluminium anodes is the subject of the next section.

Specific Resistance of the Film Formed with Phosphates.

The most important work done on leakage current is that of Burgess and Hambuechen.[5] They determined the leakage current with both direct and alternating pressure, and they found the latter to give the larger leakage current making all possible allowance for the capacity effect. They showed that as cathode the hydrogen disrupts the film and destroys it in spots; so on reversal of the current, repair must be made on these spots before the insulation becomes effective. They found that aqueous solutions (of phosphates, borax, etc.) require much longer time for effecting this repair than certain fused[6] electrolytes. With the latter, the time was reduced to 1/1100 second at the beginning of the sine wave.

Experiments were made by the author to determine the resistance of the film formed in disodium hydrogen phosphate solutions. Some conditions are of minor importance, such as the concentration of the electrolyte and the size of the electrode; others are of great importance, such as the temperature, the purity of the electrolyte and the effect of incomplete formation of the film.[7] The addition of sulphuric acid reduces the insulating effect, and the addition of halogen salts[8] destroys it. The effect of increasing the temperature is bad, as Pollak and others have observed. An aluminium anode (effective area, 15 sq. cm.) and a lead cathode were used on a direct current circuit in an electrolytic cell containing 1/10 normal solution of disodium hydrogen phosphate. (A saturated solution would have behaved in the same way).

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[1] Electrochemical Industry, July, 1904.
[2] See discussion by Prof. Aryton in connection with a paper of Taylor and Inglis. Chemical News (London), 86, page 285, November 28, 1902.
[3] Wien. Akad. Ber. 96, page 827, 1888.
[4] See Comptes Rendus, 49, p. 402, September 19, 1859.
[5] See Trans. Am. Electrochem. Soc. 1, p. 147, 1902. Western Electrician, 30, p. 273, 1902. The Wisconsin Engineer, 7, December, 1902. Electrochemical Industry, January, 1903. U. S. P., No. 732, 616, June, 1903. Electrical Review (New York), 44, p. 319, February 27, 1904. Scientific American Supplement, No. 1478, p. 23,679, April 30, 1904.
[6] Discovered by Hambuechen in 1900-1901.
[7] See previous paper, loc. cit.
[8] See Taylor and Inglis, Phil. Mag. (6), 5, 301 (1903).

The steady current was read at increasing voltages. A few of these values are given in Table I. They are plotted on Fig. 2.

TABLE I.—EFFECT OF TEMPERATURE ON FILM RESISTANCE.

Volts.	Amp.	Temp.	Volts.	Amp.	Temp.	Volts.	Amp.	Temp.
137	.008	22° C	180	.015	52° C	187	.006	80°C
164	.006	22	150	.040	52	153	.008	80
207	.017	22	175	.100	52	172	.014	80
			199	.33	52	206	.054	80
Current Reversed, Aluminium now Cathode.								
68	.380	22	51	.59	52	63	.462	80

The voltage lost in the cell resistance was roughly determined in each case by reversing the current. (The aluminium then became the cathode and acted like other metals.)

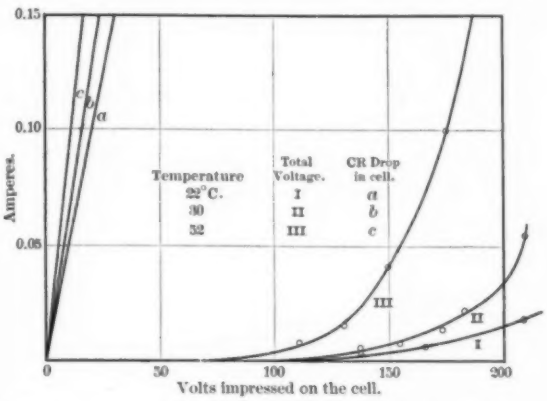


FIG. 2.—CURVES SHOWING THE EFFECT OF TEMPERATURE UPON ANODE RESISTANCE.

No correction was made for the two or three volts lost in decomposing the solution. The curves, given in Plate I., show the *great decrease in resistance of the film* accompanying a slight rise in temperature. For an increase in temperature of 10° C. the resistance of the film at 140 volts is decreased nearly one-half, so that the current is nearly doubled. This large temperature on the resistance does not occur with aqueous solutions or with metals. Aqueous solutions would decrease in resistance from 20 to 30 per cent for a rise of 10° Centigrade, while metals would increase 2 to 4 per cent in resistance for the same temperature change. Solid salts and fused salts possess, however, this enormous temperature coefficient. They decrease in resistance about 100 times for a rise of 50° C., or their resistance decreases one-half for about 7° C. rise. This is very nearly of the same order of magnitude, as the change in resistance for the film with equal rise in temperature. But this is not the only analogy to the resistance of solids.

The actual specific resistance of the film is of the same order as that observed with other solid electrolytes. Special experiments were made to obtain the minimum current at 100 volts with an aluminium electrode with an effective area of 200 sq. cm. The steady current at 25° C. was reduced to 0.002 ampere.

$$R = \frac{E}{C} = \frac{100}{0.002} = 50{,}000 \text{ ohms.}$$

Resistance per square centimeter of aluminium surface = 10,000,000 ohms. Since the thickness of the film at this voltage is about 0.0001 centimeter, therefore the specific resistance per cubic centimeter is

$$100{,}000{,}000{,}000 \text{ ohms} = 10.0 \times 10^{10} \text{ ohms.}$$

This resistance is what was expected. It is over a million times greater than the specific resistance of concentrated aqueous solutions of electrolytes.

SPECIFIC RESISTANCE OF THE FILM FORMED WITH SULPHATES.

The leakage on the direct current[9] with sulphate solutions has been determined by a number of experimenters. The data given by Beetz, Streintz, Wilson, Naccari and others is not sufficiently satisfactory to quote here. The currents observed were rather large. Several sources of error explain this. High temperature, impure electrolyte and incomplete formation of the film, all cause large leakage currents.

The best data has been obtained by Lecher, König and Cook. Lecher using a 10 per cent alum solution, obtained at 10 volts a current density of 0.00013 (and less) amp. per sq. cm. König used a saturated alum solution at room temperature. At 10 volts, the leakage current was 0.000005 ampere per sq. cm.; and this increased to 0.000017 ampere per sq. cm. at 20 volts. Cook also obtained his data with an alum solution. His work is summarized in the following table. The current density is given in ampere per sq. cm.

Temperature.	1° C.	23° C.	48° C.	58° C.
10 V	.000005	.000012	.000029	.0011
20	.000016	.000040	.000076	.002
30	.000029	.0008	.001	
40	.000152			
50	.002			

At 10 volts and 23° C., the leakage current is .000012 ampere per sq. cm. So the resistance offered to a direct current by a square centimeter of aluminium surface amounts to nearly a million (800,000) ohms. Assuming the film has a thickness of 0.0001 cm., then the specific resistance calculates out as 0.8×10^{10} ohms per cubic centimeter. This is less than that obtained with phosphates.

The dried film has a resistance (no longer asymmetrical) of this same order of magnitude. Wilson showed that a film formed on an aluminium anode (effective area 53 sq. cm.) in sulphate solutions had, when dried, a resistance 10,000 ohms at 16 volts. Wilson put the aluminium anode with its dry film in mercury and measured the current. The resistance per square centimeter of aluminium surface calculates out as 530,000 ohms.

The temperature coefficient of the film formed with the sulphates is large. It follows the logarithmic law and so great is the decrease in resistance with increase in temperature, that the effect of change in thickness of the film is hardly noticeable. This leads to an explanation of critical voltages.

CRITICAL VOLTAGES.

The critical voltage is the maximum voltage which an electrode will stand without breaking down. The critical current density is the current density at the critical voltage. Critical conditions exist when a slight increase in voltage and current cause so much additional heating of the film as to overbalance the cooling effect completely, and thus all control is lost of the current, since the resistance decreases as a logarithmic function of the temperature, while the cooling effect increases merely as a linear function of the temperature. Aluminium anodes are always hot near the critical voltage, even if they are immersed in an ice cold electrolyte. Beetz made special note of this heating effect, but Lecher tested it in the best way. He put a thermometer inside a hollow aluminium electrode and found the temperature to be above 80° C. at the critical voltage in alum solution. Any means of increasing the cooling effect will raise the critical voltage. By internal cooling of the aluminium anode, Fischer has raised the critical voltage with sulphate solutions from 20 to 220 volts. Additional evidence in great plenty might be cited in support of this resistance theory of critical voltages.

DIELECTRIC STRENGTH.

The insulating power of the film depends upon its thickness.

[9] On alternating circuits Wippermann (1898) found from current and voltage curves of an aluminum rectifier with sulphate solution that there is seldom more than 70 per cent of the current rectified.

A film formed at 100 volts must be capable of insulating the aluminium to that extent. If the dielectric strength of solids and liquids is directly proportional to their thickness, 100 volts would pierce mica 0.00005 cm. thick; glass 0.0004 cm. thick, or oil 0.002 cm. thick. On this basis, the dielectric strength of the film formed with phosphates is nearly as good as mica. To pierce one centimeter of the film would require 1,000,000 volts. The dielectric strength of films formed with sulphates is much smaller than that formed with phosphates.

Specific Inductive Capacity.

This property is fundamental to the well-known aluminium electrolytic condenser. High discharge potentials, due to this condenser effect, have been observed by a number of experimenters; Tait (1869), Beetz (1875), Slouguinoff (1878), Streintz (1887), Pollak, Graetz (1896), Dina (1898), Naccari (1901), Isenberg (1903) and Cook (1904). The best experimental work yet published on this point is that obtained by Cook. But all this data is of no use for determining the magnitude of the capacity. The following is a summary of the important data bearing on this point.

Tait (1869) observed that the polarization of an aluminium anode in sulphuric acid is quick to decrease. Krieg (1886) made observations of equivalent effect as regards aluminium electrodes in a sodium chloride solution. But already, in 1883, Oberbeck had measured with alternating currents the capacity of various metals in this electrolyte (sodium chloride). Oberbeck obtained values as follows:

Silver	0.60	micr. per sq. mm.
Gold	0.30	" " "
Palladium	0.27	" " "
Platinum	0.18	" " "
Aluminium	0.05	" " "

Oberbeck calculated the thickness of the dielectric for an equivalent air-condenser; but he used "microfarads per square millimeter," instead of "microfarads per square centimeter," and so his calculated thickness is one hundred times too small. The small capacity of aluminium, and the consequent thicker dielectric was explained by Oberbeck as due to a layer of oxide or hydroxide on the aluminium surface. The thickness of the dielectric for the air-condenser equivalent to the aluminium condenser should be .00000001768 cm. Streintz (1888) gives the first numerical data on the capacity of the aluminium electrolytic condenser using high voltages with dilute sulphuric acid solution. The time for discharging the condenser was roughly observed and from this the capacity calculated out as 1 to 3 microfarads per sq. cm.

In 1897, considerable work was published on the aluminium condenser by Malagoli, Haagn and Pollak. Malagoli obtained current and voltage curves[10] of the aluminium condenser on alternating circuits. Haagn observed a capacity effect of nearly one-half microfarad with aluminium electrodes in sulphate solution. Pollak wrote an interesting paper for the French Academy of Science, but he gave no numerical data. The work thus started led to a great deal of additional investigation.

Wilson (1898) found a capacity of 0.15 microfarads per sq. cm. in sulphate solutions near the critical voltage. Mitkiewicz (1901) obtained with a 7 per cent solution of sodium carbonate, a capacity of about 0.2 microfarads per sq. cm. Franchetti (1901), following the work of Andrews on aluminium electrodes in potassium sodium tartrate, found at 87.5 volts, a capacity of 0.058 microfarads per sq. cm. Campbell (1902) has noticed that with increasing voltages the capacity decreases. Trowbridge and Wolcott (1902) have observed at 1.5 volts that the capacity of the aluminium electrolytic condenser is of the same order as that obtained with other metals in sulphate solution. This result was to be expected in view of Scott's work.

Scott (1899), working in Nernst's laboratory, produced an especially valuable piece of research on electrolytic condensers. He measured the capacity of various metals, including aluminum both as anode and cathode. With hydrogen polarization on aluminium electrodes, he found a capacity of 10 to 15 microfarads per sq. cm. As anode, the capacity decreases greatly with increase in voltage.

Capacity of Aluminium Anode.

Volts.	Micro. per sq. cm.
0.0	8.8
0.64	5.73
1.07	4.81
1.75	3.76
0.0	3.72

Scott obtained at higher voltages capacities still lower, even below 0.05 microfarads per sq. cm.

Nodon (1903) claimed a capacity of 1 farad per sq. cm. for the aluminium electrolytic condenser; but 1 microfarad must have been meant, since he calculates the thickness of an equivalent air-condenser as 10^{-8} cm., that is, of the molecular order.

Zimmerman (1904) says: "The electrostatic capacity of 110-volt aluminium condensers may be said to be roughly ¼ to ½ microfarad per square inch of aluminium plate in the cell."

This summary of work done gives a good idea of the difficulty of obtaining reliable results, results that can be duplicated. The curve on Fig. 3 shows how rapid the decrease is in capacity with increase in voltage for sulphates.

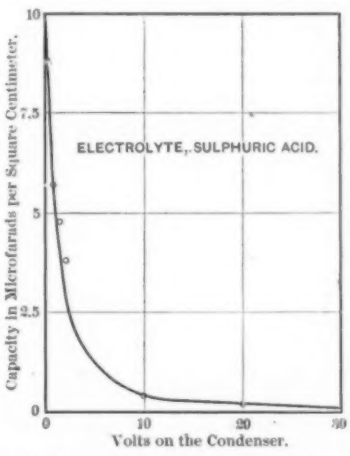


FIG. 3.—CAPACITY OF THE ALUMINIUM ELECTROLYTIC CONDENSER. (DATA GIVEN BY SCOTT.)

Calculations can now be made relative to the specific inductive capacity. The standard capacity formula is:

$$C = K \frac{S}{4\pi d}$$

where C is the capacity in electrostatic C. G. S. units, K is the specific inductive capacity, s is the area in square centimeters, and d is the thickness in centimeters. One electrostatic unit of capacity is equal to 1.11×10^{-6} microfarads.

The following table will be found convenient for reference. Capacity per square centimeter is given for different thicknesses and different dielectric constants.

	Dielectric Constant.		
Thickness	1	10	100
.000001 cm.	.0884	.884	8.84
.00001	.00884	.0884	.884
.0001	.000884	.00884	.0884

Of these three dielectric constants, it would seem comparatively easy to select the best one.

A dielectric constant of one is easily ruled out as not acceptable. Even with the ordinary electrolytic condenser, the analogy to the air condenser does not hold. Under certain conditions platinum may show a capacity of over 5000 microfarads per sq. cm. The thickness of an equivalent air condenser would be 1/200 of the diameter of a hydrogen mole-

[10] Similar work has been done by Wilson (1898 and 1902), Fessenden (1899), Mayrhofer (1900), and others. The main fact established was the formation of a leading current. The best work in this direction is that of Mr. C. I. Zimmerman. (See Trans. Am. Electro. Soc., Vol. V, page 147, 1904). Capacity effects have been observed in connection with the aluminum electroyltic rectifier. Most of the current and voltage curves obtained in this connection show capacity effects, as has been pointed out by Burgess and Hambuechen. See also the work of Wippermann and Grisson.

cule. Such results cast discredit upon the ordinary theory of electrolytic condensers. The problem is more complicated than generally assumed, since it is the meeting ground for atomic, molecular, electrical and optical phenomena.

In the case of the aluminium electrolytic condenser the dielectric film is known to be composed of substances which never give dielectric constants as low as one. A large content of water and hydroxyl radical tends to give a high dielectric constant to the film. If the film were altogether water, the maximum limit of the specific inductive capacity would be 80. The data given by Scott and Wilson on the sulphate would indicate a high dielectric constant. Zimmerman, apparently, favors the high values of the dielectric constant.

In a tentative way the author favors a value of order of magnitude of 10 which he considers "fairly satisfactory." The chief support given this value was found in the following calculations. The capacity of aluminium in phosphate solution was found equal to .013 microfarads at about 100 volts. The thickness of the dielectric film was assumed equal to .0001 cm. From this, value of $K = 15$.

Many difficulties due to *incomplete formation* or *over-formation* of the film make calculations of the dielectric constant unreliable. There is also a strong possibility that the film is a complex structure in which the real dielectric layer is thinner than the total film. Again, the effect of forming the film at different voltages and in different electrolytes must have some effect upon the specific inductive capacity.

In conclusion, the exact determination of the dielectric constant must be made with detached films.

SUMMARY.

Specific resistances have been obtained of the films that form on aluminium anodes in phosphate solutions and in sulphate solutions as respectively 10.0×10^{10} ohms per cu. cm., and 0.8×10^{10} ohms per cu. cm. at about 25° C. The specific resistance of the solid film decreases as a logarithmic function of the temperature. This leads to a definition of what critical voltage and current really mean, *i. e.*, the voltage and current at which the heating effect can be just balanced by the cooling effects. Critical voltages may be raised hundreds of per cent by increasing the cooling effect. This may be done by using cold electrolyte, by vigorous stirring of the electrolyte, and by internally cooling the electrode. A position is thus reached of mathematically treating the phenomena of critical voltages.

The dielectric strength of films formed with phosphate solutions calculates out as 1,000,000 volts per centimeter.

The specific inductive capacity of the film has been calculated and discussed, with the result that while a value of 10 is, tentatively, considered "fairly satisfactory," yet a great deal more reliable data is required for an unqualified statement."

The theory of film resistance that has been developed in this paper for aluminium anodes can probably be applied with equal success to electrodes of other metals, such as Mg, Cr, Bi, Pb, Cu, etc.

[11] The author anticipates that such data will be furnished by Mr. C. I. Zimmerman, who has done so much valuable work on the aluminium electrolytic condenser.

A LABORATORY COURSE IN INDUSTRIAL CHEMISTRY.—An interesting paper on this subject, by Dr. William H. Walker of the Massachusetts Institute of Technology, is published in the *Technological Review*, vol. VI., No. 2. Dr. Walker points out that, aside from familiarizing the student with some of those pieces of general apparatus which adapt themselves to reproduction and operation on a laboratory scale, there is not a great deal in a lecture course on industrial chemistry that can be efficiently emphasized by work in a laboratory. Nevertheless, in such a course the student obtains a new point of view—what might be termed the economics of chemistry. A good introductory exercise is the purification of common salt. The influence of the mechanical difficulties inherent in carrying on a given process as contrasted with the cost of raw materials is well shown in the preparation of barium nitrate, etc.

ELECTROLYTIC PRODUCTION OF ZINC AND LEAD FROM COMPLEX SULPHIDE ORES.

BY CHARLES H. BURLEIGH.

"Refractory zinc sulphides," so-called, may be roughly divided into two classes of ores. First, those ores which are valuable on account of their lead, gold, silver or copper contents, or some mixture of these, together with 7, 10, 12 or more per cent of zinc, and which cannot profitably be smelted. Second, those ores whose values lie chiefly in their zinc contents, but which cannot be profitably distilled, owing to the presence of iron, lead, etc.

These classes blend into each other. In fact, the question of transportation, price of labor or of coal, scarcity of water, etc., may settle into which class an ore should be placed.

In both these classes the usual way of treating them is to separate the zinc sulphides from the other sulphides by crushing and wet concentration, or by crushing and magnetic concentration with or without some roasting, or by a mixture of both methods. When the zinc sulphide crystals are large (coarse crystals) and readily separable, one of these methods is usually satisfactory.

But when the crystals of zinc sulphides are very small and intermixed very intimately with crystals of other sulphides—those of iron, lead, copper, etc., are most common—so that a given piece of ore, 1/50 of an inch in diameter, for example, contains both zinc and other crystals or zinc in chemical union with one of them, as in "Black Jack," it is not possible that any mechanical or magnetic method of separation can be even fairly good. The Broken Hill slimes in Australia and similar slimes in this country are cases in point. A great many mines which have ores carrying zinc, make a class of middlings which carry too much zinc to be smelted, and too much iron, etc., to be retorted at a profit.

In regard to the first class of ores, the problem is to get rid of the zinc, or at least enough of it, so that the balance of the ore can be smelted. The saving of zinc values is a secondary consideration and often a negligible factor.

In the second class of ores, the problem is to save the zinc values and remove the other sulphides as cheaply as possible, saving the last only when it pays to do so.

A method of saving the zinc and lead as pig metal, leaving the gold, silver, copper, iron, etc., with the gangue, to be smelted or otherwise treated as each case demands, becomes of value.

The means employed may be divided into six stages. Crushing, roasting, extracting, filtering, plating lead, plating zinc.

The crushing may be done by Blake crusher, followed by coarse roughing rolls and then by fine finishing rolls, if necessary. The ore must be crushed to such a degree of fineness that it cannot only be properly roasted, but also left in such a condition that the electrolyte, a solution of soda, can reach every particle of zinc oxide and sulphate and lead oxide and sulphate in the ore and bring it into solution. The proper degree of fineness is different in various ores and ranges between 8 and 40 mesh. Excessive fineness—sliming—is not objectionable; usually the finer the ore the quicker the extraction.

The roasting of the ore is almost an art of itself; it is the most difficult part of the process, because zinc ores are not readily soluble in a solution of soda unless properly roasted, and both the character of the ore and the character of the roast have a very great influence upon the degree of solubility. An instance is recalled where the ore, carrying about 32 per cent Zn, 8 per cent Pb, 14 per cent Fe, was nearly "sweet roasted," containing 18/100 of one per cent sulphur. It was impossible to extract more than 46 to 48 per cent of the contained zinc. Another part of the same lot of ore, when roasted hastily down to about 3½ per cent sulphur gave an extraction of 78 per cent. It took nearly ten days to solve this problem and find out why an ore high in sulphur should give a fair extraction, while one low in sulphur gave a very poor one.

This was thoroughly gone into by an eminent mining engineer assisted by some of the faculty of his alma mater. While the investigation was pending a change was made in the manner of firing and the trouble disappeared.

It is useless to expect a good zinc extraction if, during the process of roasting, the ore is made insoluble. It is desirable to roast as much of the ore as possible to an oxide, and leave as much of the remaining sulphur as possible in the sulphide rather than in the sulphate state. A good roast is an absolute necessity; it is at this point that greatest care should be used, because here the greatest obstacles are met with. The quality of the roast determines the percentage of zinc extraction; it determines the extent to which the solution shall be loaded up with sulphate which increases the amount of inert solution and adds bulk without solvent power; and it also determines whether in rare cases of a poor roast, ferrate and ferrite compounds are formed, to give trouble later.

Each ore should be taken as a fresh problem to be solved; once solved, the conditions should be maintained. The order, "Don't touch the air passage, keep the line of red-hot ore up to the seventh door," was sufficient to give a satisfactory product of about 10,000 pounds of well roasted ore daily, for over a month. The furnace used on this occasion was both self-feeding and automatically stirred.

The extraction is accomplished by running the roasted ore into a vat, about 7 ft. diameter and 8 ft. high, containing a hot solution of soda, which is stirred and kept hot until oxides and sulphates of lead and zinc have gone into solution. The time necessary to extract these may vary from 4 to 12 hours. The chemical characteristics and frequently its fineness, have marked influence on the time required for a thorough extraction. Usually practically all of the lead and 80 to 95 per cent of the zinc is extracted.

The filtration of the hot mass is done satisfactorily in a filter press; one with 24-inch x 24-inch plates is a good size to use. The greatest trouble that occurs here is in getting the residue, which is left in the press, free from solution. This residue, which is composed of undecomposed zinc, iron, gold, silver, copper and gangue, is hereafter called "tailings." Frequent washings, while the tailings are still within the press, drive out nearly all of the solution. The extent to which the solution is washed out is determined by the number of washings. The amount of water added to the solution in filtering usually balances that lost through the system by evaporation, etc. Any excess must be concentrated by boiling. The "tailings" from the filter press may in some cases be immediately treated by cyanide to recover the precious metals, in other cases they may be treated by some smelting process.

The solution which runs from the filter press should now contain lead and zinc; this is run into cells which are designed for the plating of lead. The voltage used ranges from about 1.5 volts to 1.7 volts. If the voltage falls much below 1.5 volts, lead plating stops; if it goes much above 1.7 volts there is danger that some zinc may be plated out with the lead, as zinc begins to plate out slowly at about 1.9 volts. If the voltage is kept within the limits, there are no traces of zinc in the deposited lead.

Lead plating gives rise to no difficulties; rich solutions deposit large crystals which often drop off the cathode and fall to the bottom of the cell. As the solution grows weaker in lead, the lead deposited becomes spongy, until finally the lead deposited from a weak solution floats on its surface.

All of this lead, both dense crystals and spongy mass, is taken out of the cell, the solution is pressed out and then it is run into pig metal, of great purity, immediately. In this respect lead differs from zinc; because in less than twenty-four hours after ore goes into the digester, its lead content may be put into pig metal, while zinc may require as many days of plating before the zinc is thick enough to warrant melting up; especially is this true if a low amperage per square foot is employed.

After all of the lead has been plated out of the solution, the latter passes to the zinc cells where that metal is plated out. With a properly designed cell and electrodes—in view of some business and patent matters, it is necessary to use some reticence in matters of description—there is no difficulty in varying both voltage and amperes per square foot within very wide limits. Equally good plating has been done using both 10 and 200 amperes per square foot, and between 2.5 and 7 volts upon a cathode having an area of about 6 square feet. This is about as large a cathode as two men can readily handle after it has been plated until it is about an inch thick.

There are some financial considerations which control within certain limits, the number of amperes used per square foot of cathode surface. These considerations spring from the fact that an increase of voltage accompanies an increase of amperage, so that when zinc is deposited very rapidly, it takes more watts to deposit a pound of it than it does when it is deposited more slowly. To put it another way, it costs more electric power to deposit zinc if five volts are used than it does when two and one-half volts are used. Theoretical current efficiency requires 376 ampere-hours to deposit a pound of zinc. In practice this has been done using less than 400 ampere-hours; in some cases the theoretical efficiency has been approached very closely in practice, and a 95 per cent efficiency has often been attained.

Anodes can be made of several very satisfactory materials; carbon is one of the best of these. Some makes of carbon do not stand well; others, however, do not seem to be affected by the solution and apparently stand indefinitely. The writer uses a specially made anode that has proved to be very satisfactory.

Several metals and alloys are suitable for cathodes. Of these metals, zinc is the best or one of the best, and iron the worst as zinc forms a couple with it. It does not matter much what material is used, as after a few minutes plating you have a zinc cathode, and it continues a zinc cathode until the zinc is stripped off of it. It is, of course, desirable to strip off the plated zinc and use the same cathode again and again. Various kinds of paint have been tried, also lead cathodes covered with graphite and oil, and with a view of causing the zinc to strip off easily; some of these are fairly good ways. The best way, however, is to plate the cathode with a layer of spongy zinc at first, this will take fifteen minutes and the dense reguline metal is then plated on and over the spongy zinc. It is then not difficult to split the plated zinc off the cathode. Of course, in regular plating operations no spongy zinc can be allowed, nor is it.

In regard to the pitting of plates, spongy zinc, and the evolution of hydrogen, on which subject reams have been written, it may not be out of place to suggest that, so far as hydrogen is concerned, there has not been any satisfactory proof advanced that hydrogen is in any way the cause of either spongy zinc or pitted plates. It would be very gratifying to learn how hydrogen in any way, shape or manner affects the face of any plate. My own experience tends to show that hydrogen has no chemical or electrical effect on the plate; by lying on the face of the plate it serves to lessen the cross-sectional area of the liquid conductor and may possibly slightly raise the voltage, but it is not certain that a layer of hydrogen on the face of a plate does any more harm than a layer of inert gas or a layer of air would do under like circumstances.

Hydrogen seems to be a special messenger from the gods of the chemical world—whose mission is to declare: "there is something rotten in Denmark," so far as plating is concerned. When it makes its appearance the conditions must be changed or the plate will go "bad." Hydrogen appears to be an effect, not a cause of poor plating, pitting, spongy zinc, etc., and so far as experience shows is a negligible factor.

The presence of iron in the solution is of vastly more significance. In the first place a small percentage of iron spoils zinc, and in the second place, if it is deposited from the solution, it tends to dissolve any molecule or small particle of zinc

that it touches, by forming an electric couple with it, and when one small particle of zinc is dissolved another may be attacked and then another, till a hole is eaten through the plate.

There are several ways of getting rid of the iron in a solution, but they are all bad from a business standpoint, as they all cost money. The best way to treat the iron question is to keep it out of the solution, which may be done by proper roasting and proper handling of the solution.

The strength of the solution within certain wide limits seems to have but little influence on plating; 25 and 40 per cent of soda plate equally well; when hot, the last-named is very hard on the hands, and is apt to cause trouble, if, as sometimes happens, a leak occurs; however, it dissolves the lead and zinc in the ore more quickly than a weaker solution. With a solution in proper shape and working with a correctly designed cell, the plating of zinc is about the simplest and easiest operation in electrometallurgy.

If a cathode is properly started and let alone till it is taken out, care being taken to keep the cell supplied with plenty of a suitable plating solution, the result will be a dense hard coherent deposit of zinc easily melted, free from oxide, of great purity and having a tensile strength greater than that of cast zinc. When a suitable plating solution is spoken of, one is meant that contains at least 30 mgs. per cc. or about 3 per cent of zinc.

The solution is returned to the extracting vats to treat new ore whenever the zinc content falls below 30 mgs. per cc. It is charged when it contains about 4 pounds of zinc to 10 pounds of soda. This is a good rule to work by, although very strong solutions carry a little more zinc than the rule calls for.

At this point it may well be asked, "How much does it cost to treat a ton of ore by this method? How much will a plant cost? How much does the solution deteriorate? What percentage of lead and zinc are saved?"

The answers will be different for different localities, as labor, materials, power and ores vary. An average price per ton may be, however, put at $8.00 per ton of ore treated under average conditions. Some ores in favored localities, not rich in zinc, can be treated at a cost of $4 to $5 per ton. With richer ores the cost might amount to $12.00 or $15.00 in some localities. Such cases will be very rare.

The average plant which treats ten tons of ore daily will cost approximately from $20,000 to $30,000; in larger plants the plant cost per ton of ore treated would be naturally somewhat less than in smaller plants. The solution, after runs of four, five and eight months' duration, showed no signs of deterioration, and has always plated well, and no better on the first day of the run than on the last day.

As the solution charged with zinc and lead leaves the digester, passing in succession through the filter press, lead and zinc cells and is then again returned to the digester to treat fresh ore, its only source of loss is that of solution lost in the "tailings," which is small and always reckoned as a part of the daily expense.

By this method practically all of the lead remaining in the roasted ore is saved as metal and from 80 to 90 per cent of the zinc—a fair average would be in the neighborhood of 85 per cent.

In preparing this paper it was thought best to omit all generalizations derived from laboratory experiments, and to use only those facts drawn from the writer's experience, which have been tested and proved on a commercial scale.

South Berwick, Maine.

The New York Edison Co. has recently issued a map of New York City, showing the supply network of the Edison Co. in the boroughs of Manhattan and the Bronx. The arc light mains are distiguished from the general service mains for light and power. The company supplies current as far uptown as Two Hundredth Street.

THE MANUFACTURE OF SODIUM BY THE BECKER PROCESS.

By C. F. CARRIER, JR.

In Vol. IX. of the *Monographieen über angewandte Elektrochemie*, in an article entitled "Die Elektrometallurgie der Alkalimetalle," the author, H. Becker, describes a new process[1] which he has devised, and which he states is in practical operation in France in the Usines de Rioupéroux (Isère). The apparatus involved, however (Fig. 1), does not show any remarkable variations from that invented by Castner (Fig. 2). The collecting device D is somewhat different from that of Castner, in that it serves at the same time as cathode. This,

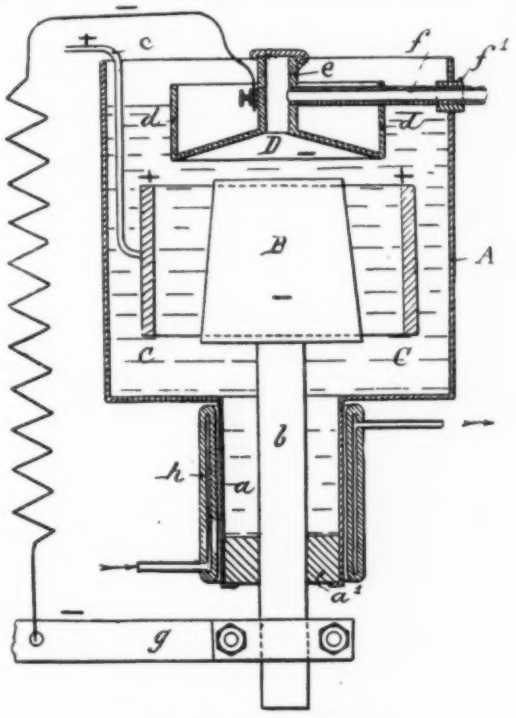


FIG. 1.—BECKER APPARATUS.

as well as the cooling arrangement *h*, may be quite essential precautions; for the process, as is shown later, is carried out at a temperature over 200° higher than that required in that of Castner. The greatest distinction is the absence of the fine mesh wire screen diaphragm which Castner considered absolutely essential to the success of the process, a requirement which this investigation fully substantiates[2]. In the absence of such a diaphragm, the sodium globules will be carried to the anode by the strong currents in the electrolyte, and oxidized. Such a diaphragm has practically no resistance, therefore it would seem that its omission is a very questionable improvement.

Becker states on page 56 of the above-mentioned monograph that his patent covers the preparation of sodium from an electrolyte consisting of sodium hydroxide, to which sodium carbonate or other sodium salt has been added, and refers to U. S. Patent 663,719. Upon reading this patent through, however, one is somewhat astonished to find that the patent only covers the apparatus.

The advantage of the new electrolyte over pure sodium hydroxide should consist in its cheapness. Concerning the proportions in which the mixture is to be made no statement is given, the only hint being that between anode and cathode, at a temperature of 550° C., the electrolyte is fluid, while in

[1] German Patent 104,955, of 1, 21, '99. U. S. Patent 663,719. ELECTROCHEMICAL INDUSTRY, Vol. I, p. 574.
[2] See also Fischer, Zeit. f. Elektrochemie, 7, p. 350 (1900).

other portions of the apparatus it is but partially so. From an example given, the yield can be calculated. An apparatus for using 5000 amperes is said to produce 40 kg. of sodium in twenty-four hours. This is about 40 per cent of the theoretical efficiency, or practically the same as in the Castner process.

A close investigation of the reactions involved in the electrolysis of such a mixture falls far short of clearing up the theory of the process. The addition of sodium carbonate to sodium hydroxide is without purpose unless it takes part in the electrolysis and free CO_2 escapes at the anode. Further, the two components must take part in the process in the same proportion in which they exist in the electrolyte, for the inventor proposes to replace the decomposed electrolyte by continuous addition of fresh mixture. If the decomposition does not take place in these proportions, or if only one component is decomposed, the entire process is calculated upon a false premise.

According to investigations of Le Blanc and Brode[3] the electrolysis of pure sodium hydroxide without a diaphragm can never give an ampere-hour efficiency of over 50 per cent, for half of the sodium is recombined by the water produced from the union of OH ions at the anode. With pure sodium carbonate, however, a theoretical yield of 100 per cent would be

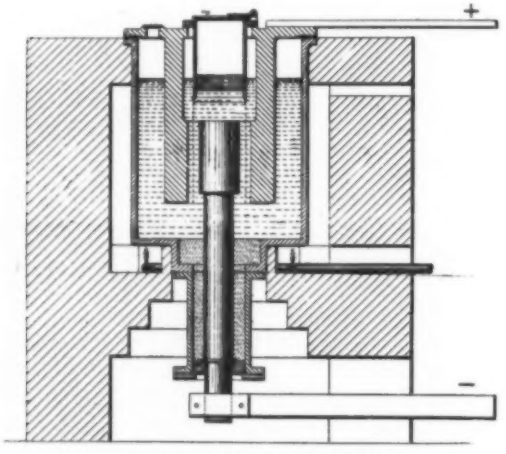


FIG. 2.—CASTNER APPARATUS.

possible, if no difficulties were introduced by the higher temperature required. If, now, sodium hydroxide and sodium carbonate are both decomposed the yield might be expected to lie between 50 and 100 per cent, but by the inventor's own example this has been shown not to be the case. This would seem to indicate that the sodium carbonate takes very small part in the electrolysis.

Starting from another point of view, the same conclusion may be reached. According to new determinations by Lebeau[4], the dissociation pressure of sodium carbonate at 700° is 1 mm. Hg.; at 730° it is 15 mm. and at 880° it is 10 mm. Inasmuch as the partial pressure of the CO_2 in the atmosphere is about 0.2 mm., it is quite probable that at 550°, in absence of moisture, sodium oxide would unite with the CO_2 to form carbonate, rather than that sodium carbonate should be decomposed. For the formation of sodium hydroxide the water vapor comes into play: $Na_2CO_3 + H_2O \rightleftharpoons 2NaOH + CO_2$. Even in the presence of water vapor, however, it is not certain that any considerable quantity of NaOH can exist at 550° (see Dammer). Just as doubtful is the possibility that CO_2 can be freed from a molten mixture of sodium hydroxide and sodium carbonate. This is only possible when the absorption capacity of the electrolyte is smaller than the rate of production of the CO_2. The following investigation was, therefore, undertaken to clear up these uncertainties.

[3] Zeit. f. Elektrochemie, 8, p. 717 (1902).
[4] Compt. Rend., 137, 1255 (1903).

Starting with pure sodium hydroxide, a series of mixtures was made by successive additions of sodium carbonate, the electrolysis being carried on continuously. These melted mixtures showed the properties of a solution of two substances which do not build mixed crystals, that is, they give two melting-point curves which cut each other at a eutectic point (approximately 255°). The object of this research, however, was not to fix these curves, so the temperatures determined in Table I. are not the true solidifying points but are the points at which one component had separated to such an extent that the electrolyte was no longer fluid enough for practical use. This point was naturally not sharp, but the approximate temperature was noted and the electrolysis carried out at that, or at a somewhat higher temperature, the anode gas being tested for CO_2.

The apparatus consisted of a cast-iron kettle 15 cm. wide and 10 cm. deep, for containing the electrolyte, the electrodes and means for collecting the anode gas. The electrodes were made of 1 cm. nickel rod, the anode being surrounded by an iron bell for collecting the gases, and both dipping 3 to 4 cm. into the electrolyte. The gas was passed through barium hydroxide solution to test for CO_2. The current density was 0.66 ampere per sq. cm. The results of the first series are shown in Table I.:

TABLE I.

% Na_2CO_3.	Temp.	Volt.	Amp.	Remarks.
16.6	265	7.0	4	No CO_2. No Na above 280°
23.1	255	8.4	6	" " 285°
28.6	265	8.0	6	" " 280°
33.3	270	9.0	8	" " 290°
37.5	285	7.8	8	" " 310°
41.2	300	7.8	8	" " 325°
44.4	310	7.5	8	" " 345°
47.4	330	6.9	8	" " 380°
50.0	350	6.1	8	" " 430°
52.4	390	6.0	8	Temperature less sharp.
55.5	430	5.8	8	Na freed up to 480°.
56.5	475	5.8	8	
58.3	510	5.7	8	
60.0	550	5.7	8	Na up to 550° but very little. No CO_2 throughout.

The separate mixtures were prepared by successive additions of carbonate during the progress of the electrolysis, at least fifteen minutes being allowed before the addition of fresh material. The current was passed for over six hours, but during the entire period not a trace of CO_2 was to be detected. It is also to be noted that even at somewhat higher temperatures Na may still be obtained, if that temperature is held as nearly as possible to the melting point of the mixture, although finally the yield decreases. This shows that Castner's observations concerning the electrolysis of pure sodium hydroxide hold also for higher temperatures when a mixed electrolyte is used.

Inasmuch as Becker states 550° as the temperature involved in his process, a second series of mixtures containing a high percentage of carbonate was prepared (and the current density increased to 1.5 ampere per sq. cm. The temperatures given in this and the following experiments are the temperatures at which the electrolysis was carried out:

TABLE II.

% Na_2CO_3.	Temp.	Volt.	Amp.	Remarks.
60.0	550°	5.1	20	Little Na. No CO_2.
62.9	580	5.0	20	Not entirely fluid at 550°.
62.5	550	6.0	20	More Na, but no CO_2.
60.6	480	5.8	20	Electrolyte hardly fluid.
50.0	440	5.7	20	No CO_2. Time, 1 hour.
50.0	480	6.0	20	No CO_2. Time, 45 minutes.
50.0	550	—	20	No CO_2. Time, 30 minutes.

The total time was 3 hours, but no CO_2 was detected.

A further increase in the current density and the percentage

of carbonate did not alter the result. Current density, 2.5 amperes per sq. cm.[5]

TABLE III.

% Na_2CO_3.	Temp.	Volt.	Amp.	Remarks.
60.0	580°	—	30	Little Na. No CO_2.
62.5	620	—	30	Less " "
64.7	630	4.3	30	No " "
66.6	630	—	30	No " "

This last mixture was still partly fluid at 600°, but in the presence of the atmosphere the sodium is oxidized or redissolved as fast as formed. The electrolysis was discontinued at the end of one hour.

The escape of CO_2 into the atmosphere could be greatly facilitated by passing a strong current of air free from CO_2, through the electrolyte in the vicinity of the anode. This was accomplished by means of the arrangement shown in Fig. 3.

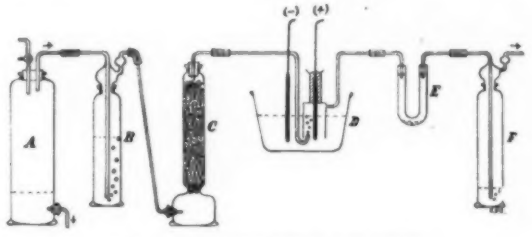


FIG. 3.—ARRANGEMENT OF TEST.

A is an air blower; B contains concentrated H_2SO_4; C contains soda-lime; D is the container for the electrolyte; E serves to retain any particles mechanically carried over, and F contains barium hydroxide solution to detect any CO_2. To remove all excess of water the ingredients were strongly heated for two hours before mixing. The results were as follows:

TABLE IV.

% Na_2CO_3	Temp.	Volt.	Amp.	Remarks.
50.0	530	3.6	20	Time, 15 min. No CO_2.
53.7	560	3.8	27	Time, 20 min. No CO_2. Some Na.
57.1	550	3.8	27	Slight precipitate in F.
61.1	530	—	27	Solid salt on bottom of D.

At the end of two hours and forty minutes, a very small quantity of barium carbonate had formed in the wash bottle F. This amounted to 0.28 gram, a yield of 0.13 per cent, but it is more probable that the large volume of air forced through was not absolutely free from CO_2, or minute portions of the electrolyte may have been carried through the tube E.

With the somewhat high potential used in Series I. and II., it is not impossible that double decomposition took place, the iron bell or the containing vessel acting as a bi-polar electrode, in which case the anode gas would contain more or less hydrogen. Even if this were the case, the results would still be of value, for it can hardly be assumed that every trace of CO_2 would be recombined. Further, above 400° any admixture of hydrogen such as would result from double electrolysis makes itself evident by an explosion, a point quite forcibly impressed upon the author in an experiment not here described.

Notwithstanding, it was decided to make another series of experiments in which any double electrolysis would be absolutely impossible. This was accomplished by cutting off the bottom of the anode bell and substituting nickel screen for the impermeable portion removed. The apparatus was also arranged so that the volume of gas evolved at the anode could be measured and compared with a gas coulombmeter in circuit with it. The current density was about 0.5 ampere per sq. cm. Results are shown in Table V.:

[5] The current density at the anode in the Castner process is about 1.64 amp. per square centimeter. (ELECTROCHEMICAL INDUSTRY, Vol. I, p. 15).

TABLE V.

% Na_2CO_3.	Temp.	Volt.	Amp.	Time.	cc. Coulomb meter gas.	cc. Anode gas.	% yield.
38.8	300°	4.8	10.0	4′	490	155	95.1
38.8	325	4.7	9.3	4′ 30″	480	154	96.3
52.7	500	3.4	10.3	4′	495	65	39.4
52.7	500	3.4	10.2	4′	485	67	41.6

Specially noteworthy is the 55 per cent decrease in the yield of anode gas at the higher temperature. This would seem to indicate the formation of sodium peroxide, a circumstance which could not help but have an unfavorable influence on a process carried out at 550°.

Again no CO_2 was to be detected. An analysis by means of pyrogallol in a Bunte burette showed the gas to be over 95 per cent oxygen. The remaining gas was probably nitrogen, as the sample was taken only fifteen minutes after the operation was started, a time insufficient to enable such a comparatively weak gas current to fully expel the air.

Finally, an experiment was made which bears upon this subject, although indirectly. Will CO_2 be given off by the electrolysis of a solution of sodium carbonate in the presence of sodium hydroxide? Fig. 4 shows the arrangement of the apparatus used. The anode consisted of a nickel plate with

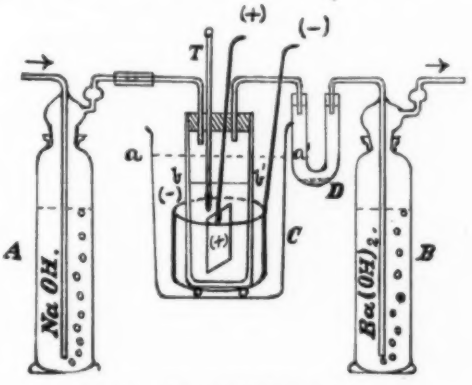


FIG. 4.—ARRANGEMENT OF TEST.

16 sq. cm. of active surface, which was contained in a porous cup. The upper portion of the cup was made air-tight by coating with japan down to the line *b b′*. A strong current of air was drawn through by suction. The figure readily explains the other portions of the apparatus.

(1) The anode compartment contained 100 cc. of 2n Na_2CO_3. Temperature, 90° to 97°. Current, 10 amperes. Precipitate began to form in the wash-flask B at the end of 2.5 minutes.

At first glance this time seems a little long, but it has been shown by Kuester and Grueters[6] that bicarbonate is formed in a pure solution of carbonate under the slight partial pressure of the atmospheric CO_2.

(2) The anode compartment contained 95 cc. of 2n. Na_2CO_3 + 5 cc. of 2n. NaOH. Current, 9.3 amperes. Temperature, 90° to 96°. First precipitate after 4.5 minutes.

(3.) The anode compartment contained 90 cc. of 2n. Na_2CO_3 + 10 cc. of 2n. NaOH. Current, 9.2 amperes. Temperature, 90° to 95°. First precipitate after 6.5 minutes.

From this it will be seen that the presence of 5 cc. of 2n. NaOH increases by two minutes the time required to produce the first precipitate. This is equivalent to 0.4 gram of NaOH. To neutralize this quantity of sodium hydroxide requires as much CO_2 as would be freed by 965 ampere-seconds. In the above cases 1116 and 1104 ampere-seconds were used within two minutes, which is equivalent to O.HOg NaOH. In other words no CO_2 was evolved until all the sodium hydroxide in the anode compartment was neutralized.

[6] B. B. 36, p. 743 (1903).

Conclusions.

Between 260° and 630°, and with current densities not greater than 2.5 amperes per sq. cm., no CO_2 was obtained by the electrolysis of mixtures of sodium hydroxide and sodium carbonate, in which the carbonate content was increased to 66 per cent. From this we must conclude that the Becker process, as described by the inventor, cannot be carried out, and that inasmuch as only sodium hydroxide is decomposed, it is nothing more or less than an inferior Castner process. Also from water solutions of sodium carbonate containing sodium hydroxide, at a temperature of 90°, and a current density of 0.6 ampere per sq. cm., it is impossible to obtain CO_2 by electrolysis until all the hydroxide is neutralized.

Institute of Physical Chemistry and Electrochemistry of the Technische Hochschule in Karlsruhe, Germany.

GERMAN BUNSEN SOCIETY.

Report of the Ninth General Meeting in Bonn.

By H. Danneel, Ph. D.

(*Concluded from page 315.*)

On the Formation of Glasses.

Prof. Tammann, of Göttingen, presented a paper on this subject. He divides all substances (aside from the old classification into solid, liquid, and gaseous) into isotropic (or amorphous) substances and anisotropic (or crystalline) substances. To the former class belong all substances except crystals. The transition from the amorphous to the crystalline state is of special importance in the production of glass. This transition depends upon two factors: (1) upon the number of nuclei of crystallization, and (2) upon the rapidity with which the single crystals grow. With suitable apparatus the number of nuclei of crystallization can be counted, and it was found by such counting that in nearly all substances the number of nuclei increases as over-cooling is increased.

A curve drawn with the number of nuclei as ordinate and the degree of over-cooling as abscissæ is convex towards the axis of abscissæ; that is to say, the rate of increase is accelerated. At a certain temperature (generally about 100° below the melting point) the curve has a maximum, and then sinks, becoming again convex to the axis of abscissæ. The rapidity of crystallization also depends upon the temperature; it increases with rising temperature, then remains constant for a while, and later decreases. The speaker discussed the details of these phenomena, and the influence of heat of crystallization upon the curves; this heat may produce a considerable rise of temperature. If amorphous sodium silicate is heated to 500°, it suddenly crystallizes, and at the same time the temperature rises by about 160°.

The possibility of working amorphous substances, such as glass, is determined by the dependence on temperature of the three properties: number of nuclei of crystallization, rapidity of crystallization, and viscosity. In the range of temperature in which glass is worked the number of nuclei must be very small, and the viscosity must not increase rapidly with the temperature. One hundred and fifty-three substances were investigated as to their ability to form glass. Fourteen per cent could be but slightly under-cooled; the rest to a greater extent. Thirty-eight per cent could very easily be obtained in the state of glass; besides these, glass is easily obtained from many silicates, phosphates, vanadinates, sulphides, oxides, and from some of the non-metallic elements. In organic substances, the ability of forming glass depends upon the constitution.

The properties of substances do not change at the transition from the liquid to the amorphous condition, but undergo extraordinary changes at the transition from the amorphous to the crystalline condition. This seems to be especially the case with the internal energy, for amorphous substances have a greater energy of reaction than crystalline ones.

Slags.

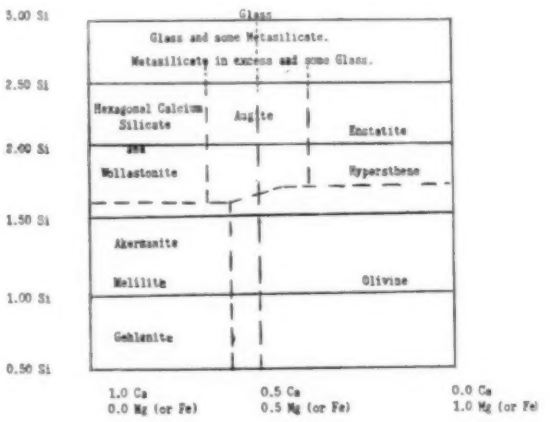
A paper on the origin of the slags in metallurgical processes, the constitution of slags and their industrial utilization, was presented by Prof. Mathesius, of Charlottenburg. He divides slags into (1) oxides or sulphides of metals, which are returned to the metallurgical works for the sake of winning the metal contained in them, and (2) those which are applied for other purposes, or are treated as rubbish. The former are mineralogically identified as spinells; the latter form the subject of the present paper.

Among the silicates the following used to be formerly distinguished: Subsilicates, $9RO.3SiO_2$; singulosilicates, $6RO.3SiO_2$; sesquisilicates, $4RO.3SiO_2$; bisilicates, $3RO.3SiO_2$; and trisilicates, $2RO.3SiO_2$. It has recently been shown, however, that in reality only the orthosilicates $6RO.3SiO_2$, and metasilicates, $3RO.3SiO_2$ exist, and that the other substances are combinations between the base and the orthosilicate, or between silicic acid and the metasilicate. The spinells are formed only when the basicity is very high. Fused mixtures of silicates have recently been treated in detail in an excellent book by Vogt, of Christiania.

The relations here existing are best seen from the accompanying diagram, in which the abscissæ is the composition with respect to bases, and the ordinate is the degree of silicization.

Vogt's Table of the Silicates.

Time of solidification, about one hour.



The most important slags at present are those from the iron smelting furnace, above all, Thomas slag, on account of its valuable contents of phosphorus.

As for utilization, the silicic acid slags are used chiefly for the manufacture of Portland cement. Enormous quantities of blast furnace slag are produced; in Rheinland, for instance, there are iron works which yield up to 3,000,000 kilograms of blast furnace slag per day. In the days when wood charcoal was used, the slag could be used directly as building material, because it offered great resistance to atmospheric influences; but now the slags from the coal furnaces are thrown upon the rubbish heap. After the worthless slags have fallen to pieces, that which has remained intact is picked out and is used in building roads.

In recent times the rest of the material has also been successfully put to use in various ways. At first the so-called Puzzolan cement was made from it, but this turned out not to have much tenacity; more recently the basic slags have been loosened with superheated steam, mixed with Portland cement, and sold as Portland cement; a practice to which the Portland cement factories object with good reason.

A further application of the slag is made by mixing it with dust from the furnace top and re-introducing it into the blast furnace. Finally, as concerns the Thomas slag, its importance

in agriculture is well known; the difficulty due to the injury to the health of those engaged in pulverizing it has now been overcome by the invention of modern crushing mills.

SESSION OF SATURDAY MORNING, MAY 14.

A report was presented by the Committee on Units. A new determination of the gas constant R is to be made. The old Mohr liter, which is still used by some factories, instead of the true liter, should be definitely discarded and forbidden.

ON HYLOTROPY.

Professor W. OSTWALD, of Leipzig, presented a paper on this subject. He gave first an interpretation of the phase rule, differing somewhat from the ordinary one. The conception of "phase" and that of "constituent" are usually considered as equivalent. But the definition of a "constituent" is not quite certain; and the speaker shows that this conception can be entirely avoided.

The new formulation of the phase rule can best be shown by some examples. When only a single substance, for instance, water, is present, then from any phase any assigned coexistent phase can be produced. When, however, several substances are present, as in the case of a solution, where it is customary to speak of two (or more) constituents, then any assigned phase cannot be produced from only a single other one, but several phases must be taken. In every case it can be determined experimentally how many phases are necessary to produce any assigned phase; and the number of necessary phases replaces in the phase equation the number of "constituents." The rule thus takes the following form: The number of co-existent phases necessary to produce any phase whatever, plus the number of degrees of freedom is equal to the number of phases actually present in the system, plus two.

The speaker discusses further the difference between so-called pure substances and solutions. A difference between the two can be observed only when one phase is formed from another, as in distillation or crystallization. In such a process there are two possibilities: (1) the remainder may be unchanged and retain the properties which it had at the start of the process, as in the case of distillation of pure water or pure alcohol; or (2) the remainder may become different from the original fluid, as in the case of the distillation of solutions. The speaker calls the first class of substances hylotropic.

A further distinction of two cases can now be made. The first of these cases is exemplified by the so-called "acids of constant boiling point," which, when temperature and pressure are kept constant, yield a distillate of the same composition as the original fluid; but if the pressure or temperature is varied, the distillate takes on a different composition from the residue (the "hylotropy" disappears). The second case is exemplified by pure water; pressure and temperature can be varied, and yet the distillate remains the same as the residue. But even this case has limits as to the choice of temperature and pressure, for at very high temperatures dissociation of the water takes place, and substances of different composition from that of the residue are obtained.

Finally, substances which remain hylotropic under all experimental conditions that we can produce, are to be called elements. Thus the chemical element is defined as a substance which retains its hylotropy under all conditions; and the difference between elements and compounds lies, not so much in the ultimate nature of the two classes of substances, as in the extent to which they possess a certain quality—hylotropy. From this point of view Prof. Ostwald treats the law of constant proportions and of combining weights; he shows that these conceptions can be defined without using the atomic hypothesis. He emphasizes the fact, however, that this is in no manner a disproof of the atomic hypothesis, but merely goes to show that it is not indispensable.

A discussion of this paper took place, in which Van't Hoff, Nernst, and Roozeboom took part.

ELECTROCHEMICAL REDUCTIONS.

Prof. K. ELBS, of Giessen, in a paper on stereochemical obstructions in electrochemical reductions, stated that in the electrochemical reduction of nitrochinolines in alkaline solution, ana-nitro-o-toluchinoline behaves differentely from ana-nitro-p-toluchinoline and ana-nitro-m-xylochinoline. The former gives azoxy- and azo-derivatives, while the two latter give the corresponding aminochinolines. This phenomenon is independent of the potential, and the ring nitrogen atom has no influence. Azo-substances are always obtained in the electrolytic reduction of aromatic mono-nitro-compounds with nickel cathodes in alkaline solutions; for the direct products of reduction, nitroso-aryl and aryl-hydroxylamine rapidly condense in the presence of alkali to azoxy-compounds, and the reduction remains in the azo-series.

Exceptions occur in the case of o- and p- nitro-amines, and the o- and p- nitro-phenoles, of which the nitroso- and hydroxylamine- derivatives change into chino-derivatives, which are reduced to amines.[1] The disappearance of the nitroso-aryl accounts for the fact that a series of o-nitro-azo-compounds do not yield any poly-azo-compounds; as soon as the nitro group here is reduced to the nitroso group, and the azo group to the hydrazo group, condensation to phentriazoles occurs.[2]

The cause of the abnormal behavior of some nitrochinolines, however, must be looked for elsewhere; it can be accounted for by a "stereochemical obstruction." Prof. Elbs explained this stereochemical obstruction in detail.

In the discussion which followed, Dr. Anschütz stated that reactions with stereochemical obstruction have been found also in purely chemical experiments. Salicylic acid is attacked by phosphorus pentachloride; but if some other radical stands near to the OH-group, then it is no longer attacked. Further discussion, by Goldschmidt, Elbs, Ostwald, and Löb, took place.

ON THE CATALYTIC ACTION OF CYANOGEN IONS.

A paper on this subject was presented by Prof. BREDIG, of Heidelberg. In the presence of cyanides, benzaldehyde condenses very rapidly to benzyl benzoate: $2C_6H_5COH = C_6H_5COCHOHC_6H_5$. Measurements of the velocity of reaction showed that with reference to aldehyde the reaction is of the second order, that is to say, when the temperature and the quantity of potassium cyanide are constant, the velocity is proportional to the second power of the concentration of the benzaldehyde:

$$\frac{dx}{dt} = k.(a - x)^2$$

where a is the original concentration of the benzaldehyde, x the quantity decomposed after t minutes, and k is the constant of velocity. During the reaction the quantity of KCN does not change. The velocity is proportional to the concentration of the KCN; but the KCN may be replaced by the cyanide of any other alkali, provided only it is as much dissociated as KCN. From this it may be concluded that the catalytic action is exerted, not by the KN itself, but by the cyanogen ion.

If the number of cyanogen ions is diminished by the addition of other substances, such as silver chloride, then the velocity of reaction becomes very much smaller. The speaker gives a formula for the reaction, by the addition of a cyanogen ion to benzaldehyde, a nitrile of mandelic acid is produced at first, which reacts with the aldehyde still present, forming benzyl benzoate and reproducing the cyanogen ion.

In the discussion which followed, Dr. Bodenstein called attention to the fact that in Prof. Bredig's experiments, which were made in a solution in alcohol (60 per cent), the conditions are the same as in solutions in water; that therefore the

[1] Elbs, Zeitschr. f. Electroch., 7, 133-138; 141-146 (1900).
[2] Elbs and Keiper, Journ. Phys. Chem., 67, 580-584 (1903).

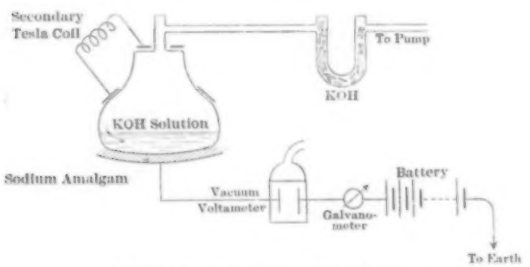
applicability of the theory of solutions to such mixed solutions is proved by these experiments.

Contribution to the Chemistry of Cathode Rays.

A paper on this subject was presented by Dr. E. Bose, of Göttingen. According to the electron theory the phenomena at the cathode in electrolysis consist in the freely movable negative electrons passing out of the cathode and then producing chemical reduction. If this view is correct, the introduction of negative electrons in any other manner ought to produce a similar effect; such introduction of electrons can be effected by exposure to cathode rays. Dr. E. Bose, of Göttingen, set himself the problem of ascertaining whether the action of the cathode rays follows Faraday's law.

The experiments are quite difficult; they have first given the qualitative result that the action of the cathode rays is always one of reduction, as would be expected. Since the experiments had to be carried out in a rather high vacuum, ordinary solutions could not be used, on account of their high vaper tension. Concentrated sulphuric acid or phosphoric acid are not suitable, because the phenomena at the cathode are not simple enough; not only hydrogen, but also other products of reduction appear at the cathode. Dr. Bose, therefore, used concentrated potassium hydroxide solution, in which the phenomena at the cathode consist *only* in the generation of hydrogen.

In order to avoid any influence of the metal submerged in the solution, the investigation was carried on in a vessel which contained no metals whatever. The apparatus was arranged as follows: A vacuum discharge tube of the form shown in the figure, designed to give the electrolyte in its bottom a large



ARRANGEMENT OF APPARATUS.

surface for small volume, was provided at the top with two metal rings, which were connected with the secondary of a Tesla coil. The vessel stood upon a platinum plate; sodium amalgam was placed between the plate and the vessel. From the platinum plate, connections were made through a vacuum voltameter, a galvanometer, and a battery of 3000 volts, and then to the earth; the battery serves to draw the negative electrons more easily through the glass walls of the vessel. At the top of the vessel is a tube which leads to the pump. An oxyhydrogen voltameter with large electrode surfaces and concentrated potash solution under low pressure was used. With such a voltameter, currents of a millionth of an ampere can be measured when the duration of the experiment is not too short. The Tesla transformer was especially simple; its primary coil contained inductance and capacity at the same time. When the experiments were made, the plate at the bottom of the vessel was charged to + 3000 volts, so that the high resistance of the glass could be more easily overcome.

Much more gas was always found than corresponds to Faraday's law, and a very great deal of oxyhydrogen mixture appeared; but this is not surprising, because water vapor is dissociated by the discharge and by the high temperature. An equilibrium of dissociation between H_2O, H_2 and O_2 is reached, but is changed by pumping, so that more of the oxyhydrogen mixture is obtained as the pump is worked more frequently. But, even if the mixture is permitted to explode, still more hydrogen is obtained (sometimes twenty times more) than in the voltameter. The explanation of this observation leads to a conclusive means of deciding between the two opposite hypotheses regarding the chemical action of cathode rays.

According to Wiedemann and Schmidt the cathode rays produce a true chemical effect; for instance, when sodium chloride is exposed to the rays, a subchloride Na_2Cl is formed. On the other hand, Abegg assumes that the action of the rays produces only a physical change. Now the cathode rays represent in the first place an electric current, which undoubtedly has an electrochemical reducing action; further, the cathode rays consist of electric corpuscles of the order of magnitude of 1/1000 to 1/2000 of a hydrogen atom, and possessing a velocity of 22,000 to 50,000 kilometers per second. From this we can compute the kinetic energy of the cathode rays which carry one coulomb of electricity, as 5.45 calories. Let us now assume that the electrons falling upon the fluid are able to shatter a molecule (we may suppose that what is produced by destruction of the molecules of the solid salt, on account of the high frictional resistance, cannot diffuse out, and thus escapes detection). Then we can make the following calculation, if we assume that the heat necessary to disintegrate a molecule is equal to its heat of formation:

The cathode ray which produces electrochemically 0.116 cubic centimeters of hydrogen, has sufficient energy to produce by the disintegration of water molecules 1800 cubic centimeters of hydrogen and the corresponding quantity of oxygen. Of course, most of the mechanical energy is transformed into heat, but the calculation furnishes an explanation why so much more oxyhydrogen mixture is formed than hydrogen itself. If it is taken into account that oxygen, on account of its great solubility and for other reasons, is easily retained in the liquid, then the excess of hydrogen is explained over what would be formed according to Faraday's law. Indeed, it can be established experimentally that the oxygen is held back. From all this it appears that the prospects of confirming Faraday's law for cathode rays are not very good at present.

In the discussion Prof. Nernst remarked that Warburg found that the production of ozone by electric discharges is much greater than would correspond to Faraday's law.

On New Luminescence Phenomena.

Dr. Trautz, of Freiburg in Baden, read a paper on this subject. It is well known that many reactions which take place in the cold are accompanied by the production of light. This occurs especially frequently in the oxidation of organic substances. Also during the crystallization of certain substances a bright illumination takes place. The intensity of the light is proportional to the velocity of reaction, or of crystallization. A larger number of experiments showing luminescence were described. A very pretty lecture experiment is the following: A mixture is made in the cold, of 35 cc. of 35 per cent formaldehyde, 35 cc. of 50 per cent solution (in water) of potassium carbonate, and 35 cc. of 10 per cent solution of pyrogallol. If, then, 50 cc. of 30 per cent hydrogen peroxide are quickly added, the whole fluid glows brightly and boils over.

Fourth Session. Saturday Afternoon, May 14.

The papers presented at the fourth session related exclusively to the application of physical chemistry and electrochemistry to physiological subjects.

Results in Medicine from Freezing Point Determinations.

Dr. Schröder, of Bonn, showed how extremely important physico-chemical measurements have become in medical practice, especially cryoscopic measurements. Blood has a freezing point of —0.56° C., and irregular action of the kidneys is detected in a change of the freezing point of the blood. Dr. Schröder enumerates many other instances in which freezing point determinations may serve, not only in diagnosis, but also more especially as a means of recognizing the normal action of the internal organs of the human body.

DETERMINATION OF THE FREEZING POINT AND CONDUCTIVITY OF URINE, AND PHARMACOLOGICAL RESULTS.

PROF. DRESER, of Elberfeld, showed that determinations of the freezing point and conductivity of urine are especially capable of indicating diseases; often the numerical results obtained show at once the manner in which patients should be treated.

CHEMICAL MASS ACTION IN THE CASE OF TOXINES.

Prof. ARRHENIUS has long been engaged in the study of the chemical explanation of the action of toxines and antitoxines upon each other. It is admitted to be a fact that the cure of poisoning is to be referred to a combination between toxine and antitoxine; but the question arises whether the combination has the character of a chemical compound, or whether it represents a case of absorption. Arrhenius has shown, together with Prof. Madsen, that the reaction between tetanolysine and its antitoxine obeys a simple chemical law—the law of mass action. This furnishes an explanation for the fact that the first dose of antitoxine acts more strongly than the second, the second more strongly than the third, and so forth. The reaction, just like chemical reactions, proceeds only up to a definite state of equilibrium, in the same manner as the reaction between an acid and an alcohol, giving an ester.

Prof. Ehrlich, of Frankfort, has set up the hypothesis that the toxines consist of different substances which have a different avidity (tendency to combine) for the antitoxines; and with this assumption he has attempted to explain the phenomenon. Arrhenius shows that the course of the reaction between tetanolysine and its antitoxine is precisely the same as that between ammonia and boric acid. Ammonia is also a lysine for the red blood corpuscles, and its poisonous effect is overcome by boric acid; and it is doubtless that this reaction obeys the law of chemical mass action.

Experiments with diphtheria toxine are somewhat more complicated, because here the first dose of serum does not work the most strongly, but on the contrary has no effect at all; Ehrlich has therefore made the assumption that the part of the diphtheria toxine which acts first and accordingly has the greatest avidity for the serum, is not poisonous. Arrhenius has repeated these experiments, but has found no indication of such unpoisonous substances, and consequently thinks that Ehrlich's experiments are affected with errors. In similar manner the action of other poisons is discussed. It is interesting that acids and alkalis which tend to decompose the poisons, are effective in proportion to their concentration in H and OH ions.

Prof. Arrhenius made a reply to an article of Nernst's in the *Zeitschrift für Elektrochemie* (vol. 10, p. 377), in which the latter had questioned the applicability of the law of mass action, maintaining that the toxines and antitoxines probably give a case of so-called "false equilibrium." If equilibrium really occurs, then it should be possible, as in other chemical equilibriums, to reverse the reaction by continually withdrawing one of the substances originally present. Since the velocities of diffusion are different for toxines and antitoxines, it should be possible by dialysis to regain the poison from a completely unpoisonous mixture of diphtheria toxine and serum. In reply to all this Arrhenius announces that he has made such experiments; by diffusion through a membrane he obtained from a harmless mixture a liquid containing a deadly amount of poison.

Prof Ehrlich spoke for the point of view that the toxines in the body are held by so-called "receptors," and that the union of the toxine to these receptors takes place with different rapidity for different toxines. If diphtheria toxine is injected into the veins, it is immediately absorbed; drawing off the blood and replacing it by new blood does not prevent death. Snake poison, on the contrary, is absorbed more slowly, so that soon after injection it can be neutralized by antidotes; but later it can no longer be neutralized. Ehrlich thinks that the law of mass action is not applicable, because the toxines unquestionably are not single substances; in generating toxines the bacteria certainly produce several substances.

Prof. Nernst made the objection that the toxines are undoubtedly colloids, for which as yet it has not been possible to demonstrate the existence of any reversible processes at all. The theory of so-called immunity is also opposed to the hypothesis of reversibility.

CONTRIBUTION TO THE THEORY OF ELECTRIC STIMULATION.

Prof. W. NERNST, of Göttingen, presented a paper on the above subject. It is well known that alternating currents of very high frequency of sufficient intensity to produce light from an incandescent lamp can be passed through the body without injury, while a direct current of one thousandth of this intensity is fatal. The reason is because the alternating current has not time to produce sufficient changes of concentration in the cells. From a former research Nernst obtained a formula according to which the change in concentration, which depends upon the current i, is inversely proportional to the square root of the frequency n. This formula was verified at that time for the human body; as an indicator of the effect produced, the feeling produced by the alternating current in passing through the hand, was taken. In order to make conclusive tests, a pure sine-current must be used, or at least a machine ought to be employed which always gives current curves of the same wave form. In the present experiments Nernst used an alternating-current generator, of special design, the terminals of which were connected to a nerve and muscle preparation from a frog. One end of this preparation was fastened firmly, while the other was connected to a pointer, by which motions could be detected very accurately. The voltage of the generator was gradually increased, and then the intensity of current noted at which the first muscular contraction appeared. The test always lasted only a short time, so as to avoid fatigue effects. Before each experiment the electrical resistance of the muscle was measured. In the following table V gives the voltage, n the frequency, and i the current, as observed and as computed from the formula $i = C\sqrt{n}$ micro amperes.

V	n	$i \times 10^{-6}$, observed.	$i \times 10^{-6}$ computed.	Difference in per cent.
0.66	105	0.81	0.78	−4.2
0.66	136	0.88	0.92	+4.6
1.68	485	2.16	2.21	+2.3
1.68	960	2.41	2.47	+2.9
2.24	2230	3.85	3.73	−3.1

In consideration of the difficulty of the measurements this must be regarded as a very good agreement, and it must be concluded that the square root law holds for all frequencies between 100 and 2000.

Some experiments were made with a "singing arc," but it was found not to give a uniform alternating current. It is therefore not suitable for this research; still less suitable are the oscillatory discharges of Leyden jars, so that the experiments of Einthoven (Pflüger's Archiv., vol. 82, p. 101) are of an accidental character.

Prof. Nernst remarked that by these experiments an electrical myth as tenacious of life as the sea serpent, had finally been killed; namely, the belief that electric currents flow only upon the surface of the human body. This is also improbable on account of the high resistance of the body.

NEW MEMBERS OF THE AMERICAN ELECTROCHEMICAL SOCIETY.—At the meeting of the Board of Directors, held in Philadelphia on August 5, the following gentlemen were elected members of the Society: Joseph Clark, Jr., Stanley, Idaho; Benito Herrera, Los Angeles, Cal. At the September meeting of the Board of Directors, the names of the following gentlemen will come up for election: F. E. Schmitt, New York; James G. Marshall, Niagara Falls, N. Y.; Timothy C. Root, Buffalo, N. Y.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By George P. Scholl, Ph. D.

Electric Furnaces and Furnace Products.

Process of Smelting Compounds and Producing Carbides.—W. S. Horry, Niagara Falls, assignor to Union Carbide Co., Niagara Falls. Patent 765,838, July 26, 1904. Application filed April 13, 1904.

W. S. Horry, the well-known inventor of the rotary calcium carbide furnace bearing his name, outlines in this patent an improvement in the manufacture of carbide by the use of alternating currents. He has found that it is not only advantageous to employ an alternating current for the manufacture of carbide, but that the current efficiency is a function of the current frequency. A frequency of 25 alternations per second is inferior to that of 50 alternations, as patented some years ago by Willson. One of one hundred and twenty alternations gives a much higher yield than that of fifty, and frequencies above one hundred and thirty-three greater than those given by any commercial machines are still more advantageous. He therefore employs an alternating current of the highest frequency which will not cause undue losses by inductive drop in the current mains. While not fully able to account for the increased yield of calcium carbide due to the use of an abnormally high frequency, he is of the opinion that the molten calcium carbide, as well as the calcium oxide, acts as an electrolyte, and that a direct current or an alternating current of low frequency decomposes both the carbide and the oxide electrolytically, a considerable portion of the energy of the current being wasted in this way, instead of being converted into useful heat. The losses due to such partial electrolysis are stated to be serious on account of the high difference of potential maintained between the electrodes. As a current of higher frequency liberates a smaller amount of ions at each reversal, the anions and cations liberated at the same electrode by the reversal of the current may be assumed to more fully recombine, their chemical energy being transformed into heat of combination. The process is carried out by heating a mixture of finely divided lime and carbon in a Horry furnace with an alternating current of sufficiently high frequency to reduce the losses due to electrolytic decomposition to a practicable minimum. It is stated that while the process has been commercially utilized for the production of calcium carbide, it is obviously useful for the production of other carbides, silicides, etc., and in general for such smelting operations as are effected by heat generated by passing an electric current through the charge, and in which electrolysis is undesirable.

Electrolytic Production of Metals and Compounds.

Manufacture of Brominated Indigo.—Albrecht Schmidt and Rudolph Mueller, Hoechst-on-the-Main, Germany, Assignors to Farbwerke, vormals Meister, Lucius and Bruening. Patent 765,996, July 26.

The bromo-indigo is manufactured by electrolyzing an aqueous or sulphuric acid solution of indigo or indigo white, treated with hydrogen bromide, sodium bromide or other bromates. It is not absolutely necessary to use a diaphragm, as the hydrogen set free by electrolysis has no action in an acid solution on indigo and bromo-indigo. To obtain good yield the acid used must not be too dilute, for otherwise too many oxidation products are obtained, *e. g.*, isatin. Good results are obtained with hydrobromic acid of 40 per cent or more strength, or sulphuric acid of 50 to 78 per cent, containing hydrogen bromide. Concentrated hydrochloric acid may also be used, if sufficient hydrobromic acid is present, but its use in electrolysis is somewhat inconvenient. In carrying out the preparation of the bromo-indigo, finely-divided indigo is stirred with hydrobromic acid of 40 or more per cent strength, to a thin paste, by means of a high-speed agitator. The electrodes are best of carbon, and may be separated by a diaphragm. Hydrobromic acid serves as electrolyte and the electrolysis is carried out at about 2.5 volts and three amperes. Active stirring is kept up during electrolysis until the desired degree of bromination to the mono or dibrom substitution product is obtained. The current density is not stated. The time required to obtain the above products may be calculated from the time of electrolysis and the amperage. The process is the same with indigo white, and the use of a diaphragm is optional. Bromides, such as sodium bromide, may be added during electrolysis. The advantages of the method thus far described are stated to be, first, that only small portions of bromine act on an excess of indigo, as with proper choice of the current conditions no excess of bromine can be employed, and second, that no regeneration of hydrogen bromide is necessary. The brominated indigos thus obtained resemble in their properties those obtained by dry bromination, but whether they are identical with the latter or with the products obtained synthetically, for instance, from indoxyl, could hitherto not be observed.

Apparatus for Vacuously Depositing Metals.—Thomas A. Edison, Llewellyn Park, N. J. Patent 767,216, August 9, 1904. Application filed August 1, 1903.

The apparatus is primarily designed for coating phonograph records, and is an improvement upon the apparatus described in Mr. Edison's patent of November 18, 1902, which is illustrated in Electrochemical Industry, Vol. 1., page 219. A vertical sectional view is shown in Fig. 1. Extending through a base plate 3, preferably of glass, are glass tubes 4 carrying circuit wires 5. Electrodes 6, preferably in the shape of thin strips of foil, are depending from the wires, and a small weight 7 at the bottom of each electrode serves the purpose of keeping them flat, as the best results by the most even coatings are obtained when the electrodes are perfectly flat. The electrodes are made of the metal to be deposited, and are preferably of gold, as the latter may be highly comminuted and is of non-oxidizable character. A metal rim 8, within which is placed a glass bell jar 9, serves to make a perfectly tight joint, when filled with molten paraffin. The air is exhausted from the bell jar through pipe 11. Supports 12 within the vacuum chamber carry vertical shafts 13 with tapered ends. Surrounding each of these shafts is a sleeve 14, with hardened bearing cup 15 at the top and a disc 16 at the bot-

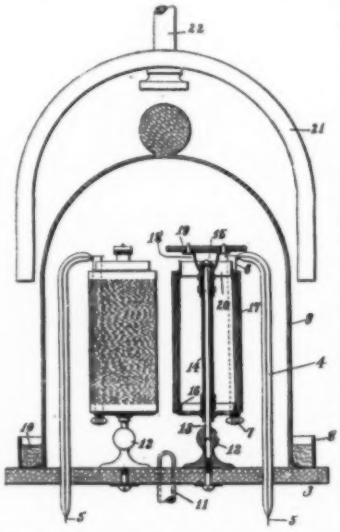


FIG. 1.—APPARATUS FOR DEPOSITING METALS IN VACUO.

tom, which disc carries the record 17, to be plated. Arms 18 extend up from the sleeve 14 and carry a movable armature 19. A guard or shield 20, preferably of brass, fits within the top of record 17 and is intended to prevent the metal from being deposited in the interior of record 17, and to cause it to deposit evenly on the latter's edge with a clear line of demarcation. A magnet 21, carried by a shaft 22, can be rotated by suitable contrivances. Two of the above-described apparatus work together, the current being switched onto them alternately so as to allow the electrodes to cool off. A suitable switch worked by clockwork regulates the switching operation. An induction coil is connected with the electrodes, after a proper vacuum has been created, the discharge being so regulated as to secure between the electrodes a silent or brush discharge, which causes the metal composing the electrodes to be vaporized and to be deposited on the records. The magnets 21 are rotated at the same time, so as to rotate the objects, whereby a perfectly uniform film will be deposited upon them. When the film is of the desired thickness, the bell jars are removed, which permits the coated records to be taken off for subsequent treatment.

STORAGE BATTERIES.

Secondary Battery.—O. H. F. C. Walter, Berlin, Germany, assignor to Pflueger Accumulatoren Werke, Berlin. Patent 766,078, July 26, 1904. Application filed December 1, 1903.

The plate in this battery consists of a grid of vertical and horizontal rods, which are covered in the usual manner with paste and dried. It is then exposed to a temperature higher than the melting point of the metal of which the plate frame is made. In the case of lead, a temperature of from 400° to 500° C. will be required, while for frames of lead and antimony, or lead, tin and antimony, etc., much lower temperatures can be used. By this means the metal forming the framework is fused out. A horizontal section of the plate is shown in Fig. 2 before and after heating. The vertical bars *a*, the horizontal ones not being shown in this section, are surrounded with the active mass *d*, and after heating, only the hollow spaces *d* remain, while a thin porous film *f* is left which holds together the separate parts of the active mass. It is stated to be quite immaterial in this process whether the plate has been treated with current or not before fusing, or whether it is old or new, or whether it is a mass plate or one which has been treated according to the Planté process. The advantages claimed for the plate are great lightness in consequence of the removal of the metal core and great capacity, because the acid reaches the active mass, not only from the outside, but also from the inside, as it penetrates through the porous metallic films *f*.

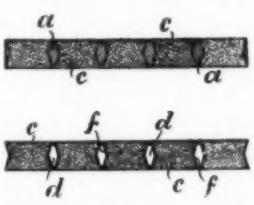


FIG. 2.—BATTERY PLATE.

Storage Battery.—F. T. Cable, New Suffolk and Grant E. Edgar, Greenport, N. Y. Patent 766,216, August 2, 1904. Application filed February 26, 1903, renewed December 19, 1903.

The invention relates to storage batteries for use on vessels, especially submarine; the object is to insulate the cells from each other, and the entire battery from the vessel, to ventilate the battery, to prevent the electrolyte from slopping over into the vessel or into other cells, and to provide for the support of the heavy elements of the cells, so as to permit the use of glass, earthenware or hard rubber receptacles. The inventors provide an inner tank which contains the cells, and an outer tank, separated from the inner one by a space, the upper part of which is partitioned off and serves to catch liquid which slops over. A current of air is maintained through another portion of the space between the two tanks, which is partitioned off below the space which serves to catch the liquid. Further details are described in the specification.

Apparatus for Washing Storage Batteries.—J. L. Lough, New York. Patent 766,365, August 2, 1904. Application filed May 17, 1904.

The inventor provides for the washing and cleansing of storage batteries, by arranging two flexible pipes at opposite ends of the battery, the free ends of which extend down to the bottom. The deposit is sucked out by means of a small rotary pump and delivered into a precipitating tank with a baffle, below which the liquid has to pass. The passage of the solution through this tank is rather slow, so that the sediment has time to settle. The clear solution returns from the top of the precipitating tank into the storage cell.

Method of Producing Elements for Electric Cells.—T. Kitsee, Philadelphia. Patent 766,504, August 2, 1904. Application filed April 14, 1902. Renewed June 16, 1904.

The invention deals with the production of electrodes for small cells and aims at avoiding the handling of the separate small electrodes when they are charged up either before or after being filled with active material. It is therefore proposed to assemble a series of small grids by connecting them by lugs, so that the whole forms a mechanical unit. This unit is then charged and after charging is finished, the lugs connecting the various small grids to each other are cut, and the latter then form the finished electrodes for the small cells.

Accumulator.—J. A. Lyons and E. C. Broadwell, Chicago. Patent 766,958, August 9, 1904. Application filed September 25, 1903.

The accumulator shown in the specification consists of a rectangular metallic receptacle with an interior lining of cotton cloth or other material. "An anode plate of graphite platino iridium or other inert substance stands in the middle of the receptacle and is surrounded by a mixture of carbonaceous material such as charcoal, etc., mixed with infusorial earth and the oxide, hydroxide or oxy-salts of such metals as give two or more forms of oxides, such as lead, nickel, cobalt, cerium or the like. This in a pasty consistency is placed around the anode, and the mass is saturated with a solution of either a basic haloid of the oxy-salt or its equivalents of the metal by the electrolysis of which deposition in a reguline state occurs at the cathode. In practice there is preferably used as the electrolytic salt zinc oxy-chloride or zinc chloride or bromide holding zinc hydroxide or oxide, or a zinc oxide bearing salt holding the zinc oxide with weak affinity in suspension or weak chemical solution, although it is evident that the basic sulphate, basic nitrate or any other oxy-salt can be utilized, and also that the oxy or other basic salts of tin, cadmium, copper or the like can be substituted for the oxy-salts of zinc, but zinc oxide or hydroxide must always, if zinc salts are used, be present in excess." The basic compounds are intended to neutralize the acid formed at the anode during electrolysis, and thus to prevent electrolysis of the acid, which would take place if the latter were not neutralized.

Insulated Battery Cell.—V. G. Apple, Dayton, Ohio. Patent 767,323, August 9, 1904. Application filed November 9, 1903.

The battery comprises a metallic containing case, either furnished with interior recesses or with perforations for the purpose of serving as support for the active material and acting as one of the electrodes of the battery. This is intimately united with an exterior coating of rubber, applied to it in such a manner that the two layers form practically an integral structure. The insulating material employed is of such a

nature that it may be applied to the metal in a softened condition and be subsequently treated so as to cause it to harden in close adhesion to the metal.

Galvanic Elements.

Primary Battery.—Thomas A. Edison, Llewellyn Park, N. J. Patent 766,815, August 9, 1904. Application filed November 18, 1903.

The invention relates to the manufacture of copper oxide electrodes for batteries of the Lelande type. Such a cell does not reach its normal discharge rate until the surface of the copper oxide is completely reduced to the metallic state, and the electrode is usually thus reduced before being placed in the cell. Mr. Edison finds that very good results can be obtained by dispensing with this preliminary reduction and rubbing instead ordinary red oxide of copper upon the surface of the electrode. As the electrode is more or less porous, the particles of the red oxide adhere very tenaciously. As the red oxide is easily reducible, the surface reduction to the metallic state progresses rapidly, so that the cell quickly reaches its full discharge rate. The copper oxide electrodes are preferably made by treating precipitated hydroxide of copper with hypochlorite of sodium, thereby producing an excessively finely divided black oxide of copper. This is dried, moistened with a solution of sodium (?), pressed into plates of the desired form and burnt in the regular manner to consolidate the mass.

Miscellaneous.

Rectifying and Interrupting Alternating Current.—W. Scheidel, Chicago. Patent 766,468, August 2, 1904. Application filed December 31, 1903.

The apparatus described in the specification is shown in Fig. 3. It is intended to be applied to inductoriums and like apparatus, which are operated by a high frequency current. It consists essentially of a vessel of aluminium 6, which when acting as anode prevents the passage of the current, but allows it to pass with but little resistance when acting as cathode. The other electrode 8 is formed of platinum wire, surrounded by a tube of insulating material 10, and projecting through a small orifice in the lower end of the tube into the electrolyte. A holder rod 9 supports the anode. The electrolyte is phosphate of soda or ammonia or other like solution generally employed in rectifier cells. A binding post 7 serves as connection for one of the alternating-current line wires to the vessel. It is claimed that this arrangement is adapted to eliminate to a very material extent the usual rapid generation of heat and increase in temperature in the ordinary form of electrolytic interrupter.

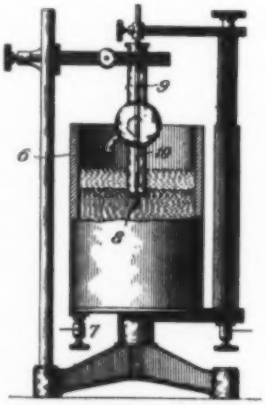


FIG. 3.—ELECTROLYTIC RECTIFIER.

Method of Purifying Water.—W. M. Jewell, Winnetka and W. J. McGee, Oak Park, Ill. Patent 766,146, July 26, 1904. Application filed January 26, 1903.

The invention consists in purifying water by introducing an insoluble reagent in powdered form into it and keeping it suspended by agitation, while subjecting the water to electrolysis at the same time. The reagent which is claimed to be best suited to play the role is barium carbonate, in the form of witherite. When the latter is introduced into a water containing sodium sulphate and electrolysis takes place, the sulphuric anion combines with the witherite to form insoluble barium sulphate, CO_2 being liberated. If the natural water does not contain enough chlorides of calcium or magnesium a quantity of calcium chloride is added, and the carbonic acid gas from calcium or magnesium carbonate leaving sodium chloride in solution, which is said not to be objectionable for most commercial purposes. The apparatus comprises a tank, which carries a vertical shaft, provided at its lower end with a cross-bar, from which depend the electrodes of lead, which are alternately positive and negative. The apparatus is described in detail.

Apparatus for Purifying Water by Electrical Means.—J. S. Zerbe, New York. Patent 767,195, August 9, 1904. Application filed May 2 1904.

The apparatus comprises a vertical electrical chamber containing alternate anodes and cathodes. The water enters at its lower end and passes up through the electrical chamber into a so-called ozonizing chamber above it, which is claimed to act as disseminator for the ozone. From there it is carried by means of a pipe to the lower end of a cylindrical vertical filtering chamber, within which is arranged a perforated shell wrapped with felt or other filtering material. On top of the first-named vessel is a little reservoir designed to catch the ozone, and a pipe leads from it to the bottom of the filtering chamber and into the interior of the perforated shell. The exit for the purified water is located at the top of the filtering chamber. One-half ampere of current per gallon per hour is stated to be generally sufficient for sterilization of the water, the voltage ranging from six to 110. Low voltage is preferable in all cases. Aluminium electrodes are preferred. The outside of the interior shell, which is covered with felt, comes into contact with a brush when turned by a hand-wheel provided for this purpose, and is thus kept clean by the removal of the accumulated impurities.

RECENT METALLURGICAL PATENTS.

Zinc.

The reduction of zinc oxide in a blast furnace by means of water gas or natural gas has attracted considerable attention for some time, and a great many experiments have been made. A stumbling block to such attempts has been the great quantity of combustion-gases and nitrogen in the zinc atmosphere, which prevented liquid condensation and resulted only in the production of zinc dust. O. Nagel has formerly patented a process of producing spelter by reducing zinc oxide in a blast furnace by means of water gas. He has now found (U. S. Patent 766,279, August 2), that hydrocarbons in gaseous or gasified condition, including, of course, coal gas and natural gas, are equal and sometimes superior to water-gas for carrying the process into effect.

The inventor states that natural gas containing from 85 to 90 per cent of methane is especially advantageous, as the concentration of zinc vapors obtained is nearly twice as large as with water-gas. He explains this theoretically by the fact that one molecule of methane combines with four atoms of oxygen and one molecule of water-gas only with two. Furthermore, the coefficient of molecular friction of methane is only about half that of water-gas, which fact explains the easy condensation of zinc in a methane atmosphere. For this reason a considerable quantity of nitrogen may become added to

methane without affecting the reducing capacity of the latter as compared with water-gas. Natural gas, with 85 to 90 per cent methane and 2 to 15 per cent nitrogen, occurs very frequently, and is said to be either superior to or equally effective as water-gas for the reduction of zinc.

When such heated hydrocarbons are passed through a zinc ore or preferably a mixture of ore with from 10 to 15 per cent of coal, the zinc oxide is reduced, the hydrocarbons being split up into carbon monoxide and hydrogen. The inventor gives the following formulas for the reversible reactions involved in the action of methane.

(1) $ZnO + CH_4 = Zn + CO + 2H_2$
(2) $ZnO + H_2 = Zn + H_2O$
(3a) $H_2O + CO = H_2 + CO_2$
(3b) $H_2O + CH_4 = CO + 3H_2$
(4) $CO_2 + CH_4 = 2CO + 2H_2$

Equation (1) represents the splitting up of the hydrocarbon. In (2) the reduction is continued, and at increasing temperature the reaction goes, as indicated in the equation when read from the left to the right; the difference of the oxidation heat of ZnO (85,000 calories) minus that of H_2O (58,000) being large (27,000). The water formed in (2) is reduced partly by carbon monoxide according to (3a), and partly by methane, according to (3b). The result of the reaction is an atmosphere practically free of oxygen, oxydizing substances, and nitrogen, thus allowing for an easy concentration of the zinc vapors to liquid metal.

COPPER.

R. Baggaley and C. M. Allen (766,654, 766,655, 766,656. August 2) patent a process of producing copper or matte without the need of water concentration and calcining and without the use of carbonaceous fuel, or with only a small percentage of such fuel. They separate the sulphide ores (low in silica and high in matte-making sulphides) from the siliceous ores (high in silica and low in matte-making materials) and use both kinds of ores as follows. The sulphide ores are smelted in a furnace with or without the use of carbonaceous fuel, to produce a low-grade matte high in fuel value, *i. e.*, high in its contents of sulphur, iron, and other oxidizable elements. The matte and slag are discharged from the smelting furnace into the usual forehearth, where the slag is separated from the matte and the matte is then drawn off from time to time.

The matte, free from slag, is then put into a converter and charges of siliceous ore (of smaller quantity than the matte) are added to the bath, while air is blown into the mixture. The blast of air oxidizes the combustible ingredients of the bath—namely, sulphur and iron and other oxidizable elements—and produces within the bath an intense heat; the oxidized iron combines with the silica of the added ore, and forms a floating slag, while the metallic compounds of the added ore are dissolved in the molten bath. The slag is drawn off from time to time, the converter being tipped for this purpose. As the matte loses its iron and sulphur, the volume of the bath decreases, new molten matte is poured in and siliceous ore is added, until the converter has received its full charge of matte, which is enriched to the extent desired, and is then poured either as converter matte or as blister copper.

The slag from the converter, which is necessarily basic, is poured upon the charge in the furnace for melting the sulphide ores and serves there the purpose of dissolving any solid accretions on the walls of the furnace; at the same time it furnishes additional heat. The siliceous ore which is gradually charged into the converter is preheated by waste gases.

R. Baggaley (766,579, August 2) patents a method of sampling plates or slabs of blister-copper. The method consists in casting the copper in plates of uniform size (17 x 24 x 2 inches) and casting on the surface of the plate 240 marks regularly distributed over the surface and indicating the location of the sampling-holes. Two hundred and forty plates of the above size make a carload, and through plate 1 a hole is drilled at mark 1, through plate 2 at mark 2, etc. The cuttings are placed into a sampling receptacle, and when assayed, are claimed to give an accurate and reliable indication of the proportions of copper and precious metals contained in the carload.

ALLOY.

R. B. Wheatley (766,085, July 26) patents an alloy of copper and zinc in the proportions found in common brass, but with certain additions intended to increase the tensile strength, the ductility and the resistivity against corrosion by atmospheric influence; it is stated that the alloy may be spun and mechanically manipulated while cold with a considerable degree of deformation without fracture. The alloy consists of 98.5 per cent of copper and zinc (present in the respective proportions of 60 and 40 per cent), the remaining 1.5 per cent being made up of tin, aluminium, iron, manganese, tungsten and strontium.

LEAD.

J. H. Mercadier (767,906, Aug. 16) patents a process for manufacturing spongy lead specially intended for storage battery plates. Molten lead is stirred by means of a fork in a receptacle; while it is cooling, it is powdered with a metal oxide, like litharge or minium or oxide of zinc or a mixture of these oxides. When the lead begins to become pasty, the receptacle is placed over a slight flame, and the lead is kneaded by means of a stirrer and continuously powdered with the oxide. When solidification has taken place, the lead is in form of an extremely porous mass, consisting of filaments soldered together and leaving interstices between them. This mass is stated to have great mechanical strength.

IRON AND STEEL.

Pipes and blowholes in steel castings are due to the presence of gases, and it has been the practice to add some aluminium which acts in a well-known manner. M. Meslans (765,932, July 26) proposes to use an alloy of aluminium and calcium—the aluminium to take care of the oxide of carbon and the calcium of the hydrogen and nitrogen gases. (The manufacture of such an alloy should not be difficult by electrochemical means.)

Scrap-steel containing a small amount or carbon cannot be converted into a high-grade commercial steel without recarbonizing in a furnace. If coke, together with the scrap steel is put into the furnace, the carbon is driven off before the steel is heated to a temperature sufficiently high to absorb the carbon in the coke. H. B. Atha (765,724 and 766,131, July 26) endeavors to prevent this by either of the following two methods. The first is to intimately mix the scrap steel with finely-divided carbon, press the mixture into bundles and treat them in the open-hearth furnace. The other is to put finely-divided carbon in a liquid, place bundles of scrap steel in this liquor, whereby they receive a coating of carbon, and treat them in the open-hearth furnace.

J. W. Arnold (765,158, July 19) patents a process of treating iron and steel preparatory to rolling it into bars. The object is to dispense with the use of dampers, the heat of one charge serving to temper the preceding charge. For this purpose he introduces the fresh, cool charge into the furnace at a point between the fire and the preceding charge, so that the latter heats the former and is itself cooled.

A method of hard-soldering pieces of cast iron (which is said to be also applicable to other metals) is described by H. F. Hiller (767,339, and 767,340, August 9). The pieces of the iron are heated red-hot and allowed to cool; the parts to be brazed are then moistened with a mixture of boracic acid (1 ounce), carmimic acid (¼ ounce), carbonate of lime (¼ ounce), water (1 quart). They are then placed in the forge and heated until they are hot enough to melt the flux, which is then added and which consists of boric-acid crystals. After

the flux has thoroughly entered the joint, a brass-copper spelter is added.

Metallurgical Furnaces.

Two patents were granted to G. H. Shellaberger for details of construction of rotary ore-roasting furnaces. One patent (765,997, July 26) refers to mechanical details of a furnace, the interior of which is divided into a plurality of longitudinal ore-chambers and interspersed heat flues, the ore being fed longitudinally through the furnace body in one direction and returned through other chambers and delivered at or near the same end into which it was fed. While the ore passes through the first chambers, it is subjected to a gentle and gradually increasing heat, so as to get dried before it comes into the actual roasting chambers. The travel of the ore through the furnace is effected by the tumbling action of the ore as the furnace body rotates so that the rate of feed is adjustable by changing the speed of rotation. The second patent (765,998, July 26) refers to a rotary furnace, the interior of which is divided into a plurality of ore-roasting chambers with interspersed heat-flues; the roasting chambers are radially disposed around a common central air-trunk; each chamber is provided with several air inlets, controlled by valves located within the air-trunk. The main air-trunk enters through, and is directly exposed within the combustion chamber of the heat generating furnace.

L. H. Allen (766,156, July 26) patents an ore-roasting furnace of the construction shown in Fig. 1, in which 10 is the revolving ore-roasting cylinder and 33 the furnace; 30 is an annular vaporizing receptacle, supplied through the pipe 41 with water; 34 and 49 are air-blast pipes. During the centrifugal movement of the ore-roasting cylinder 10, water is flowing through 41 into the vaporizing receptacle 30, generating steam. The blast of air through 49 upon the products of combustion on the furnace grate produces a reducing flame of great intensity, which is projected into the ore-roasting cylinder. "The flame affords requisite oxygen for the oxidation of the ores, and the vapor which becomes superheated from the vaporizing receptacle 30 is decomposed, the hydrogen gas evolved uniting with the oxygen in the flame and an oxy-hydrogen flame projected the length of the cylinder, and as at the outward passage the gases and products of combustion are retarded in passing out of the cylinder the overturned ores are attacked by the oxy-hydrogen gas, with which it comes in contact under pressure, the ores being scarified by the heat."

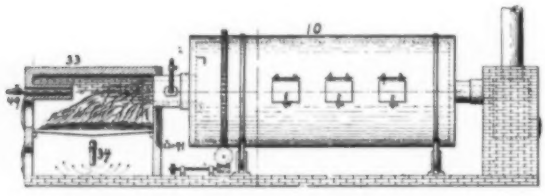


FIG. 1.—ORE ROASTING FURNACE.

L. T. Wright (12,254, August 2) patents details of construction of the rotary stirrer in the McDougall roasting furnace. Since the central shaft, the arms and the rabbles thereon are liable to be disabled by a momentary excess of heat, he provides means for cooling these parts.

J. Reuleaux (767,243, August 9) patents details of construction of a continuous heating furnace, the prime object being to prevent cinders from falling from the slabs or billets into the fuel-ports and lodge therein as well as in the supply chamber.

A patent granted to J. C. Fox (765,728, July 26) relates to the construction of muffles of the kind used by assayers for the roasting or cupellation of ores. If the air is admitted at one end of the muffle, the reaction takes place successively and is completed much earlier in the front of the muffle than at the back. To shorten the time, the inventor provides the muffle with channels or passages through which the air supply can be distributed to all parts of the charge simultaneously. These channels are formed integral with the walls of the muffle.

S. Forter (767,399, August 16) patents a feeding device for gas producers, furnaces, etc., so as to direct the charge both towards the center and the sides. A. Ronay (766,903, August 9) patents a charging device for furnaces, the prime object being to prevent the outside air from entering, or the inside gases from escaping, during the process of charging. The charging device comprises a bent charging tube having a branch connected with the furnace, and a mechanical charging device in another branch of the tube; the arrangement is so that the fuel in the bent elbow portion of the tube closes the same, to prevent the escape of gas and also protects the mechanical charging device from the heat of the furnace.

J. Kennedy (767,285, August 9) patents details of construction of a valve for furnace flues, H. R. Palmer (765,901, July 26) an air-valve mechanism for gas-burning furnaces.

S. V. Peppel (765,789, July 26) patents a method of converting furnace-flue dust into blocks, suitable for treatment in ordinary furnaces. He mixes intimately lime with the flue-dust, adds water and presses the mixture into blocks.

Slime Filtering Apparatus.

G. S. Duncan (766,025, July 26) describes a filtering apparatus for the rapid and thorough separation of gold and silver bearing solutions from finely divided residual ores or slimes. He uses a large number of hollow, flat vertical filters worked under vacuum. They are suspended within the vat containing the material to be treated and each of these filters consists of a skeleton framing covered with filter-cloth; they are arranged comparatively close and parallel to each other with scrapers between. The filters are connected on top with a pipe in communication with a vacuum tank which receives the solutions as they are filtered, while the scrapers are reciprocated between the filters at intervals to remove the muddy coating and carry it below the bottom of the filters and prevent clogging.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

Industrial Electrochemistry and Electrometallurgy.

Iron and Steel Metallurgy.—The August number of *Engineering Magazine* contains a long and profusely illustrated article by A. Minet on the application of electric furnace methods in iron and steel metallurgy. The author first makes some general remarks on the cost of power. On the basis of a price of $10.00 for an electric horse-power-year at the electrodes within the furnace, and assuming a year of 8000 hours, he gives the cost of 1 hp.-hour at 0.126 cents, 1 kw.-hour 0.172 cents, and 1000 large calories 0.2 cents (in the formulas given in the foot-note of page 797 there is some confusion in the units, for instance one kg.-meter equals 9.81 joules or watt-seconds, and not watts as stated). The author then gives some general notes on metallurgy of iron in general (among them

the somewhat peculiar remark that "the electric calories furnished by natural power are more economical than the calories set free by the combustion of coal" for roasting purposes). He then gives a review of many electric furnace processes which have been proposed, and nearly all of which have been described at length in ELECTROCHEMICAL INDUSTRY. The author divides all methods into direct methods (starting from the ore and without passing through casting) and indirect methods. Among the direct methods he gives the processes of Stassano, Heroult, Harmet, Keller, Contardo, Ruthenburg and Minet-Neuburger. The latter is illustrated in Figs. 1 and 2, the intention being to operate the furnace either by elec-

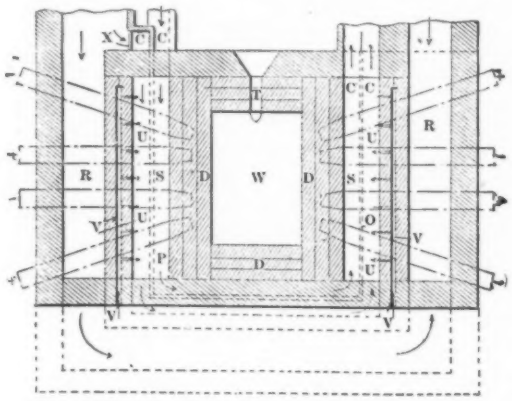


FIG. 1.—SECTION OF MINET-NEUBURGER FURNACE.

tricity or by waste blast furnace gases or by gases coming from gas works. In connection with gas engines driven by the bast furnace gases, and used as prime movers for dynamos, the furnace is intended to insure to iron works the application of most electrometallurgical processes under conditions of economy of the same order as those attained in works driven by natural power.

The furnace consists of a central chamber W, supplied with an outlet hole T, and separated from the heating chambers SSSS by partitions DDD, of which the nature varies according to the reactions and the products of the reactions. The

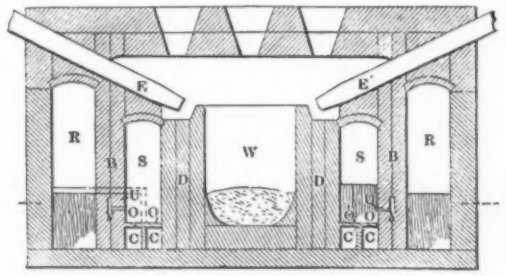


FIG. 2.—SECTION OF MINET-NEUBURGER FURNACE.

heating chambers SS receive through the holes OO either blast-furnace gases from the flues CC, or rich or poor gases from the flues C' C' coming from a gas producer or gas works; and these gases burn in the chambers SS. These chambers are separated from other reheating chambers RR by partitions BB, of refractory clay, in which are built flues U opening into the combustion chambers SS by air-holes, V. The reheating chambers RR are traversed by the blast-furnace gases, of which a part enters into the flues CC, which are provided with a regulator X, for controlling the quantity of gas which should pass into these flues. This part burns in SS; the greater part of the blast-furnace gas passes unburned from RR and is used for supplying the gas engines. The electric current is conducted by the electrodes EEE' E', which in the various cases take the positions represented. It is possible also to conduct the blast-furnace gases to the center of the reaction at VV, and to take advantage of their reducing properties or to burn them directly above the raw materials. With a furnace of this kind it is possible to obtain every temperature from 200° to 900° C., by using the blast-furnace gases alone; from 900° to 1,300° by using the blast-furnace gas with other rich gases; and from 1,300° to the temperature of the arc, by adding to these different sources of heat the action of the electric current.

The author then goes over to the discussion of indirect methods. He first describes an experiment of Hillairet and Garnier. In a refractory tube are placed end to end a stick of carbon and a rod of iron containing 0.1 per cent of carbon in such a manner that the ends in contact are about the middle of the tube. The whole is heated in a little blast furnace. During the heating a suitable continuous current is passed through the two rods, from the carbon to the iron. At the ends of three hours the iron rod is withdrawn suddenly from the tube, and cooled by immersion in water. The end of the iron rod, which was in contact with the stick of carbon, is hardened to a depth of ten millimeters to such an extent that it scratches glass. By reversing the current in another experiment it is proved that the cementation is due to the transfer of carbon into the iron by the action of the current. In this case the iron rod, through which the current now enters, remains almost unchanged. The author finally describes the processes of Laval, Gerard-Lecuyer, Kjellin and Gin.

Mercury Cathode.—Various attempts have been made to diminish as much as possible the quantity of mercury in the mercury cathode process of electrolyzing alkali chlorides. Gurwitsch has proposed for this purpose to use a vertical or inclined iron plate over the surface of which a very thin film of mercury continually flows downwards. For this purpose he directs streams of mercury from small orifices (of about 1/3 mm. diameter) against the iron plate. The adhesion between iron and alkali amalgam is so great that this thin stream expands into a strip of 25 to 30 mm. breadth. Under the influence of the electric current, however, the surface tension of the mercury would be changed, tending to contract the strip; to prevent this, Gurwitsch provides the iron plate with longitudinal grooves, the capillary action of which withstands the surface tension. W. KETTEMBEIL and C. F. CARRIER, JR., have made experiments concerning the practicability of this method, the two papers being published in the *Zeit. f. Elektrochemie*, August 5. Kettembeil found that it is difficult to amalgamate thoroughly the iron cathodes, and that it is necessary to keep them always under the influence of the electric current. Since the mercury flows downwards with great velocity, it stirs up the electrolyte, so that continually new electrolyte, charged with chlorine gas, gets into contact with the amalgam surface; this means, of course, losses which can only be prevented by using a diaphragm. Even with a porous diaphragm he obtained an ampere-hour efficiency of only 85 per cent, without it only 50 per cent. C. F. Carrier, Jr., succeeded in getting somewhat better results, due to a modification of the mechanical details of construction of the iron plate. The best results were obtained by him with a current density of 0.34 to 0.50 ampere per sq. cm.; the ampere-hour efficiency was then about 90 per cent if a diaphragm was used, and a little over 70 per cent without a diaphragm. From special experiments made for this purpose he concludes that without a diaphragm, a good efficiency can be obtained only if the mercury surface is at rest or moves only slowly and regularly. Gurwitsch's proposition seems, therefore, not promising for use in practice, since without diaphragm the efficiency is too low, while with a diaphragm the voltage is too high and the apparatus becomes too complicated.

Recovery of Tin from Scrap.—An interesting summary of electrolytic processes for recovering tin from tin scrap and

tin slags is given by J. B. Kershaw in *Elec. Rev.*, June 18. Claus used a bath of sulpho-stannate of sodium (sp. gr. 1.070), heated to about 90° C., with a current density of 10 ampere per square foot; the process does not seem to be in use at present. Garcia used a pure hot solution of ferric chloride for dissolving the tin (without the current); the solution of ferric and stannic chloride obtained in this way was then filtered, carbolic acid and sulphuric acid were added and electrolytic deposition of tin was carried out with carbon anodes and lead cathodes; the process was not a success. Gelstharpe used as electrolyte a 1.25 per cent solution of hydrochloric acid, with a small amount of sulphuric acid; tin cuttings in wooden crates were the anodes, tinned sheets the cathodes; the iron remaining after removal of the tin was worked up into crystalline ferrous sulphate. The author believes that none of the processes using acid or a mixture of acids as electrolyte, and producing ferrous sulphate or chloride as a by-product, can hope for permanent success. He then speaks briefly of the process of the Th. Goldschmidt Co. in Essen, which has been commercially very successful. The process is kept secret, but the author believes it to be an alkaline process; sodium hydrate being used as electrolyte, and the tin scrap in iron baskets being the anode. Smith & Guthensohn have patented a process, the electrolyte being composed of dilute sulphuric acid (one in ten) and tin sulphate. The author states that in several works slight modifications of the old process of Beatson are used, in which hot caustic soda solution of 1.21 sp. gr. was employed and the scrap and cuttings were used as anodes in flat boxes having wire gauze sides. Thin iron plates are used as cathodes. In order to refine the tin obtained as a powdery deposit on these plates Beatson pressed it into flat cakes, and employed them as anodes in a second depositing vat, in which a strong solution of stannous chloride or sulphate was the electrolyte, while a revolving cathode of iron or tin was used to receive the deposit, which was brought into a more dense and solid state by a pressure roller. The tin obtained in this way was finally melted and cast into ingots. The author finally gives some estimate of the operating cost; the cost of electric energy is given as $51 per ton of tin, or less than 9 per cent of the present market value of the metal. He concludes that the alkaline electrolytic process for recovery of tin from tin scrap and cuttings is one which is likely to expand into an industry of considerable importance. But the methods of collection and shipment of the scrap to special detinning works are expensive, and he thinks that tin scrap recovery plants should rather be worked as an adjunct of all large electric supply stations. This would provide them with a day load and the plant would only draw on the local supply of tin scrap and cuttings.

Electroplating.—In *Metallurgie*, August 8, W. Pfanhauser gives an illustrated description of the equipment of some modern electroplating establishments. He deals especially with electroplating zinc on iron, and remarks that the electrolytic method is now used in plants which, by size and economy of operation, are superior to plants using the old method of "hot galvanizing." In electroplating iron with zinc often the mistake is made that too thin a layer of zinc is plated. To get a good durable zinc coating, it is necessary to deposit at least 140 to 150 grams of zinc per square meter of surface; such a coating may be obtained within 30 to 35 minutes with a normal current density of 1.5 to 2.0 amperes per square decimeter. If irregular surfaces containing holes, etc., are to be electroplated with zinc, he proposes to first produce a uniform deposit of zinc from an alkaline solution, and to thicken this deposit by using afterwards the ordinary electrolyte consisting of zinc sulphate with the regular additions for the sake of increasing the conductivity.

Electrometallurgy.—In *L'Industrie Electrigure*, July 10, 25, J. Izart begins to give a review of the general status of electric furnace industries. He first discusses the application of the electric furnace in the iron and steel industries, especially for the manufacture of special steels and ferro-alloys. He deals briefly with aluminium, sodium, copper, zinc, nickel and mercury. Concerning the use of electric furnace methods in metallurgy, he thinks that they do not yield a sufficiently pure metal, except when used in combination with electrolytic action, as is the case for aluminium, sodium, etc.; in other cases the electric furnace may be useful as an auxiliary to concentrate the metallic contents of an ore near the mines, to save freight expenses.

Recent Advances in Electrochemistry.—A reprint in full of B. Blount's series of Cantor lectures on this subject (abstracts of which have already been noticed in these columns) begins in the *Jour. Soc. of Arts*, August 12.

Theoretical and Experimental.

Molecular Attraction.—In a paper, published in *Jour. of Phys. Chem.*, June, J. E. Mills endeavors to show that the attraction between molecules varies inversely as the square of their distance apart, and does not vary with the temperature. Considering the attraction as a property belonging to each molecule, or more exactly, as a mutual property of each pair of molecules, it must vary as the mass, large numbers of similar molecules being here considered. In other words, the law of gravitation holds not only between masses, but between the molecules of a substance, and this law is alone sufficient to account for the phenomenon of the internal heat of vaporization. He derives the equation that the ratio of the internal heat of vaporization to the difference of the third root of the density of the liquid and the third root of the density of the vapor should be constant. This law was tested for twenty-one substances and found perfectly correct for eleven substances; with five substances the divergencies found all occur at such points and are of such magnitude that they may easily be due to errors of observation. Stannic chloride failed to agree with the equation. To the associated substances, water, methyl, ethyl, and propyl alcohols, and acetic acid, the equation was not supposed to be applicable; but within wide limits the agreement of these substances, acetic acid excepted, is such as to suggest the conclusion that the molecular association is used by the molecular attraction.

Theory of Solutions.—Another attack on the electrolytic dissociation theory is made by J. Traube, in the *Philosophical Magazine*, August. He first sums up his objections to this theory, and then proposes a new hypothesis, in which he assumes both dissociation and association. He believes that even in the most diluted solutions in one moment every dissociation, for instance, of a molecule NaCl, is followed by an association of Na and Cl. There will be a chain of dissociations and associations, and not only a series of dissociations. "The calculation of the coefficient of dissociation is the undisputable merit of Arrhenius, but the interpretation of that coefficient we should certainly reject." According to Traube, the Arrhenius coefficient of dissociation represents "the relation of the number of particles of the electrolyte which are joined with 2, 3, etc., single molecules of the solvent and the number of its particles which are joined with one molecule of the solvent or none." He thinks it is not improbable that even at the moment when the ions are joined, every ion takes hold of its particle of the solvent, excepting in stronger solutions, where it will occur that 2, 3 ions of one molecule of them have only one single molecule of the solvent at their disposal. He applies his views to the relation between conductivity and dilution.

Porous Diaphragm.—A new form of diaphragm—or rather diaphragm support—for electrolytic cells is described by F. Mollow Perkin in a Faraday Society paper, published in *Electrochem. and Met.*, July. Cells, as shown in Fig. 3, are made of wedgewood ware or of some glazed material; in the figure the small cells are of wedgewood and the larger are salt-glazed. The actual cell consists of two portions, one fitting within the other. Thus, in the figure, where two cells are

shown, the smaller one in each case fits into the larger one. Each complete cell consists of two perforated cells, the perforations being about large enough for a pin of ordinary size to pass through; the inner or smaller cell fits loosely into the larger one. When put together, a liquid can pass readily through the complete cell, which thus, of course, does not act as a diaphragm. In order to use the cell as a diaphragm the inner cell is, for example, wrapped tightly with asbestos

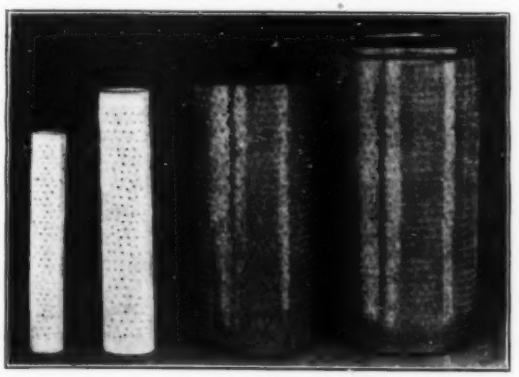


FIG. 3.—POROUS DIAPHRAGMS.

paper until it can just be passed down into the outer cell. The asbestos should be wrapped in such a manner that there is considerable overlapping at the bottom end. This is then folded over so as to practically make a bag, and when pushed home the inner cell rests tightly upon the asbestos. The cells are made so that about three folds of thin asbestos paper is sufficient to cause the one part to fit tightly into the other. The diaphragm so prepared is soaked in water or the electrolyte, such, *e. g.*, as sulphuric acid or a salt solution, and is then ready for use. When carefully packed this makes a very efficient membrane, since the two portions of the cell are, owing to the perforations, to all intents and purposes, open to the passage of the current. For most purposes, for sulphuric acid which is not stronger than 25 to 30 per cent, or for moderately strong caustic alkali, and, of course, for neutral solutions, it is not necessary to employ asbestos, ordinary filter paper making a very effective diaphragm. Parchment can also be used, or a pulp of asbestos poured into the annular space between the two cells, or a pulp of blotting paper, or coarse sand or coarsely powdered glass. Asbestos or a pulp of well-washed nitrated cotton wool can well be used even with strong acids or alkalis.

Formation of Ozone.—It is well known that with increasing temperature the stability of endothermic compounds increases. It should, therefore, be expected that at a very high temperature oxygen is changed by heat partly into ozone according to the equation $3O_2 = 2O_3$. J. K. CLEMENT has made a series of careful experiments in this direction at temperatures above 2200° C. and has found that the expected result is not obtained. His paper is published in *Annalen der Phys.*, IV. Folge, Vol. 14, 1904, page 334. He conducted a stream of pure oxygen over the surface of an incandescent Nernst filament, so that it was heated to about 2200° C., while, when streaming away, it was quickly cooled. He could not detect any formation of ozone, nor was any found at the temperature of the electrolytic arc lamp, about 3000° C., nor in experiments with a hollow Nernst filament. Whenever there were traces of nitrogen present, NO_2 was formed, which, in its reactions is very similar to ozone; and it seems to be due to this fact that former investigators thought that ozone had been formed. From Clement's researches it seems certain that the only case in which ozone is formed at a high temperature, is under the influence of the electric spark; but it is possible that in this case the formation of ozone is due solely to the action of ultraviolet light. The author also gives the results of extended researches on the speed of disintegration of ozone; on the basis of a formula of van't Hoff which can be applied to this case, he finds that at 1000° C. the content of ozone decreases in 0.0007 second from 1 per cent to 0.001 per cent; this means that if ozone is really formed at a temperature of 2200° C. or more, it must disintegrate almost instantaneously when cooled even very quickly.

Mixed Indicators.—A contribution to the theory of indicators is given by M. SCHOLTZ in the *Zeit f. Elektrochemie*, July 29. If there are several indicators simultaneously in hydrochloric acid solution, and if the solution is being gradually neutralized by caustic potash, the strongest acid will first change color, and only after a further addition of caustic potash the weaker indicator acid will change color. By observing the order in which the indicators change color, it can be determined which of the indicators is the stronger acid. As a proof of the reliability of this method, the author mentions the fact that out of 120 experiments which were made with twenty-two indicators in various combinations, there are not two which would contradict each other. The results of his experiments are given in form of tables.

Internal Friction of Solutions.—In the *Zeit f. Elektrochemie* of July 15, G. RUDORF refers to former experiments made by him, in which he believes to have found a negative value of the internal friction in certain solutions. From more recent investigations of Fawsitt, he concludes there is an error in his former measurements, due to the spiral form of capillary tube used by him. His former conclusion of the existence of a negative internal friction is now considered by him as unwarranted.

Manganese Analysis.—A quick electrolytic method of determining manganese with the use of a revolving cathode is described by J. KOESTER in the *Zeit. f. Elektrochemie*, July 29. He uses a dish of platinum-iridium as anode, while as cathode a platinum plate is used, revolving at a speed of 600 to 700 revolutions. The electrolyte (about 110 to 130 cc.) contains, besides the manganese salt (not the chloride), 5 to 10 grams of ammonium acetate, 2 to 3 grams of chrome alum, and 1 or 2 cc. alcohol. The voltage at the terminals may be about 7 for a current density of 4 to 4.5 amperes. Before the circuit is closed, the solution is heated to 75° C. and the burner is then removed. Should the temperature rise beyond 85° C. during electrolysis, some cold water is added.

Laboratory.—In the *Zeit. f. Elektrochemie*, July 15, E. COHEN describes the equipment of the new van't Hoff laboratory of physical and inorganic chemistry at the University of Utrecht. The same issue contains the speeches held at the opening of the laboratory. Van't Hoff received the honorary degree of M. D.

BATTERIES.

Accumulator Construction.—With reference to the paper of W. W. Donaldson, abstracted in our June issue, p. 245, S. H. RABENALT makes several remarks in *Elec. World and Eng.*, June 18. He thinks it is not a right principle for the construction of a Planté plate, to provide only for good electrical connections, and to hope that the mechanical will take care of themselves. The Planté positive plate has a tendency to grow and buckle, and he advises to construct such a plate of a large number of small "units," comprising the "active portion" of the plate and to weld these into a solid and rigid frame of antimonial lead; each section or unit should be joined to the frame at its upper edge only, and be allowed to follow its tendencies to expand or grow in three directions, sufficient space being provided for this purpose. Negative plates of the Planté type are neither ideal nor even desirable; batteries with Planté negatives give an exceptionally high c. e. m. f. on charge and are very susceptible to "treeing." After discussing several other points, the author speaks decidedly against Donaldson's argument that the grooves should be tightly filled in order to maintain contact between the grid

and the active mass. The fact that a groove is tightly filled will not prevent the formation of additional peroxide if condition favors a tendency for it. If the grooves are so tightly filled that they are unable to accommodate additional mass, the mass will make itself the necessary space. If the frame construction (which encloses the active portions tight, not providing for expansion space) is made out of soft lead, the plate will grow and buckle. If the frame construction is made out of antimonial lead (with a comparatively high percentage of antimony) the plate will very often crack or break.

Care of Storage Batteries.—In the London *Elec. Rev.* of July 22, an anonymous writer points out that batteries often fall into a bad condition simply on account of the bad treatment they have received. He speaks especially of the length of charge which should be given to a battery. He thinks that heavy overcharges are very deleterious to a battery. He, therefore, recommends to base the length of a charge on the number of ampere-hours taken out during the previous discharge, allowing a certain constant percentage excess. For any type of grid, the percentage excess of ampere-hours required to fully charge it is fairly constant irrespective of the discharge rate, and it is, for ordinary purposes, safe to fix this at a figure depending on the average ampere-hours efficiency, at rates which can be considered normal under the different circumstances of each case. This may be anything between 8 and 12 per cent. For this purpose the ampere-hours charge and discharge should, of course, be metered. He recommends to book the ampere-hours charge and discharge each day with the final closed-circuit voltage at the end of discharge, while hydrometer readings should be booked once a month, but taken once a week.

Storage Battery Records in Telephone Practice.—An article on this subject by H. S. Knowlton is found in *Elec. World and Eng.*, July 23. The removal of the local open circuit battery from the subscriber's station, and its replacement by the storage battery at the central office has greatly simplified the maintenance problem. Under the new conditions the breakdown of a battery at a central energy office would be a serious matter, and every possible precaution should be taken to avoid such a contingency. The author thinks one of the best methods of forestalling battery troubles is to keep a daily record accurately prepared and neatly filled in of the charging and discharging conditions, voltage, specific gravity and appearance of the cells. He describes in detail how to arrange and how to keep such records.

Lead Poisoning.—In the *Centralblatt f. Accum.*, July 1, T. Umbach states that the usual method of cleaning the hands with ordinary soap and water after having handled lead compounds is not sufficient to prevent lead poisoning. To prevent it successfully, the lead should be changed into sulphide, which is absolutely without danger to the organism. Blum recommends the use of "akreminine soap," which produces the change into the sulphide directly on the skin. (Wien. Med. Wochenschrift, No. 13.)

Miscellaneous.

Phosphorus.—An editorial in the *Metal Industry*, August, deals with the "abuse of phosphorus." It is said that the true function of phosphorus and alloys is not generally understood. Its real function is the reduction of the oxides of copper or tin, which are always found when these metals are melted, and phosphorus itself is not intended as an ingredient of the alloy. Up to a certain amount, phosphorus is a benefit in various alloys, but beyond that it acts as a positive injury. The amount necessary in phosphorus bronze is a quantity just sufficient to reduce the oxides present, and such an amount is rarely over 0.05 per cent. Contrary to the usual belief, the amount of phosphorus should decrease rather than increase, as the proportion of tin is increased. Leaving out the question of the use of scrap, it will be found for rolling mill work—*i. e.*, plates, bars or rods not in metal moulds—that 0.05 per cent of phosphorus is the proper amount, and under no consideration should more be added. For sand castings it will be advisable to use more phosphorus than that employed for rolling mill work. This is on account of the use of so much scrap, the phosphorus of which is oxidized out by repeated meltings. In order to allow for such oxidation, the excess of phosphorus is introduced. Were nothing but new metal used, 0.05 per cent of phosphorus (as given above) would be ample. If the usual run of sand casting work is made, and the material in the form of gates, risers, bad castings, etc., is repeatedly melted, then an amount of phosphorus equivalent to 0.25 per cent should be introduced. In connection with the large amount of phosphorus which is often recommended in alloys for sand castings, the writer states that in every case he has found that blow-holes were present in the castings. The user of phosphorus bronze should not introduce it in form of stick phosphorus, but in form of phosphor tin or phosphor copper.

Testing Materials.—The equipment of the new Bureau of Testing Materials of the Prussian Government which is associated with the Technische Hochschule, of Berlin, is described in *Metallurgie*, August 8. The departments for metallurgy and metallography are described in some detail. The room for heating and melting materials contains various electric furnaces which are partly of the simplest kind, made by winding nickel wire around a porcelain tube, and wrapping the whole into an insulating mass; in other furnaces the Joulean heat is produced in strips of very thin platinum foil, made by Heraeus. For rough regulation, a rheostat in series with the furnace is used, while more delicate regulation is accomplished by an adjustable resistance in shunt with the heating wire. By this means it is possible to maintain the temperature in the furnace constant within ± 3° C. and to adjust the speed of heating and cooling. For more exact work, the current is furnished from a storage battery, otherwise from the supply mains.

Copper-Zinc Alloys.—A long paper, by E. S. Shepherd, is published in the *Jour. of Phys. Chem.*, June. Copper and zinc unite to form six series of solid solutions; the author has determined the limiting concentrations of these solid solutions and gives the equilibrium diagram for the system. There are no "definite compounds" between copper and zinc. The author gives an explanation of the red color of brasses low in copper. Forty-four excellent microphotographs of the complete series are reproduced, showing the effect of heat treatment in brass.

Nickel.—A brief illustrated description of the Evje Nickel Works in Norway is given in *Metallurgie*, June 22. The monthly output is 300 tons of ore, giving about 8 tons of nickel and 3 tons of copper.

Correspondence.

LEAD PEROXIDE ANODES FOR THE CYANIDE PROCESS.

To the Editor of Electrochemical Industry:

Sir:—In my paper on "A Development in Electrolytic Precipitation of Gold and Silver from Cyanide Solutions," which you printed in your issue of April, 1904, there is one statement which I should like to supplement. On page 132 I said: "Anodes peroxidized in this way have been in use for the last ten or twelve months, and at the present time have as good a surface as on the day they were first placed in the box."

I am informed from Minas Prietas that eight or nine months after this statement was made, the anodes in question began to

show signs of wasting, and our experience is that when once the surface begins to disintegrate, deterioration is comparatively rapid.

Thus we cannot yet consider these anodes to be permanent, though they are undoubtedly the most satisfactory we have tried. E. M. HAMILTON.

Plympton S. Mary, S. Devon.

Book Reviews.

ALTERNATING CURRENTS, THEIR GENERATION, DISTRIBUTION AND UTILIZATION. By George T. Hanchett. New York: John Wiley & Sons. 175 pages, illustrated. Price $1.00.

For electric furnace processes alternating currents are in extended use and the manager of an electric furnace plant, while primarily an electrochemist or electrometallurgist, is often confronted with problems of alternating current engineering. The theory of alternating current phenomena and appartus has been splendidly worked out during the past twenty years or so, but most text books and original papers on the subject are of a highly mathematical character, and do therefore not appeal strongly to chemists.

The small book of Mr. Hanchett has been written with an endeavor to explain as clearly and simply as possible, the phenomena as well as the apparatus of alternating currents of electricity in their various practical phases. The author seems to have prepared the book primarily for the use of managers of central stations and constructing electrical engineers, but we think that in view of its plain and clear language the book should be found useful by electrochemists who want to become acquainted with alternating current engineering. The author first gives hydraulic analogies of inductance and capacity combinations and then explains the fundamental principles of alternating-current phenomena. He then deals with the single-phase constant potential transformer, discusses phase difference and vector summation, gives the calculations of copper for polyphase currents and describes the methods of alternating-current measurements. The concluding six chapters of the book deal with the induction motor, the rotary converter, alternating-current generators and synchronous motors and the management of alternating-current machinery and induction motors.

THE ALTERNATING-CURRENT TRANSFORMER. By F. G. Baum. New York: McGraw Publishing Co. 195 pages and 122 illustrations. Price $1.50.

Although of small size it is one of the most complete and exhaustive treatises on the alternating-current transformer, and the reader who carefully studies the book should gain a good working knowledge of alternating-current phenomena which should enable him to study other problems of alternating-current engineering outside of transformer practice.

The book originated from a course of lectures held at Stanford Uniersity, Cal., and some knowledge of elementary alternating-current phenomena, and of the principles of calculus is presupposed. The ten chapters of the book deal with elementary principles, the simple transformer diagram, graphical representation of pressure relations, regulation, efficiency, testing, systematic design, circuit regulators, constant current transformers, series transformers, compensating voltmeter, connections of transformers for single-phase and polyphase circuits, commercial types of transformers of American and European manufacturers. Extracts from the rules and requirements of the National Board of Fire Underwriters are printed as an appendix.

The reviewer quite agrees with the statement of the author that the student who grasps the theory of the transformer has little difficulty with the more complicated reactions in the induction motor and in synchronous apparatus.

INTERNATIONAL ELECTRICAL CONGRESS.

The International Electrical Congress will convene at the Music Hall of the Coliseum, St. Louis, on Monday, September 12, 1904, 9:30 a. m. The Music Hall is situated at Olive and Thirteenth Streets, in the city district of St. Louis. It is intended that after the opening ceremonies, the convention will immediately divide into sections, the section halls being on the second floor of the same building. The Bureau of Information and the offices of the secretary and treasurer will also be in the Coliseum Building. On Tuesday, Thursday and Friday, the Sections will meet on the second floor of the Coliseum from 9 a. m. to 1 p. m. There will be probably more than 2000 members of the Congress, of which about 75 per cent are from North America and 25 per cent from other countries.

We have already printed lists of paper to be presented in Section A, B and C on page 214 of our June issue, those of Sections D and E on page 258 of our July issue. We herewith give again a revised programme of the electrochemical section.

SECTION C—ELECTROCHEMISTRY.

Chairman of this section is Prof. Henry S. Carhart, secretary Mr. Carl Hering. The following papers will be presented:

S. Arrhenius, Methods of Determining the Degree of Dissociation.

Dr. W. Borchers, Electrometallurgy of Nickel.

Sherard Cowper-Coles, Electrolytic Methods for the Rapid Production of Copper Sheets and Tubes.

F. Dolezalek (Subject to be announced).

J. Sigfrid Edström, Electrical Extraction of Nitrogen from the Air.

Hans Goldschmidt, Alumino-Thermics.

F. Haber, Electrolytic Disturbances in the Earth.

P. L. T. Héroult, Electrometallurgy of Iron and Steel.

Richard Lorenz, Electrolysis of Fused Salts.

W. Ostwald, Electrolysis and Catalysis.

J. Swinburne, Electrolytic Smelting of Sulphide Ores.

W. D. Bancroft, The Chemistry of Electroplating. (American Electrochemical Society paper.)

A. G. Betts and Edward F. Kern, The Lead Voltameter.

H. S. Carhart and C. A. Hulett, The Preparation of Materials for Standard Cells and their Construction. (American Electrochemical Society paper.)

Thomas A. Edison, The Present Status of Alkaline Storage Batteries. (By Deputy.)

K. E. Guthe, The Silver Voltameter.

L. Kahlenberg, The Electrochemical Series of the Metals. (American Electrochemical Society paper.)

J. W. Richards, The Energy Absorbed in Electrolysis.

T. W. Richards, The Relation of the Theory of Compessible Atoms to Electrochemistry.

The *American Electrochemical Society* will hold an independent session on September 16, which will be a joint session with the Bunsen Society, and the Faraday Society, and to which the members of the Congress will also be invited.

SECTION A—GENERAL THEORY.

Chairman of this section is Prof. E. L. Nichols, secretary, Prof. H. T. Barnes. The revised list of papers is as follows:

Moise Ascoli, Systems of Electric Units.

Paul Drude, Metallic Conduction from the Standpoint of the Electronic Theory.

W. Jaeger, Electrical Standards.

H. Nagaoka, Magneto-Striction.

J. S. Townsend, The Theory of Ionization by Collision.

J. J. Thomson, The Corpuscular Theory.

M. J. Violle, Secondary Standards of Light.

C. T. R. Wilson, Condensation Nuclei.

P. Zeeman, Recent Progress in Magneto-Optics.

Howard T. Barnes, The Mechanical Equivalent of Heat Measured by Electrical Means.

Carl Barus, Atmospheric Nuclei.

L. A. Bauer, The State of Our Knowledge Regarding the Earth's Magnetism and Recent Remarkable Magnetic Storms.

D. B. Brace, Magneto-Optics.

H. S. Carhart and G. W. Patterson, Jr., The Absolute Value of the Electromotive Force of the Clark and Weston Cells.

C. D. Child, The Electric Arc.

K. E. Guthe, Coherer Action.

A. E. Kennelly, The Alternating Current Theory of Transmission-Speed over Submarine Telegraph Cables.

E. Percival Lewis, The Electrical Conductivity of Gases.

J. C. McLennan, Radio-activity of Mineral Oils and Natural Gases.

Lewis T. More, Electrostriction.

E. F. Nichols, The Unobtained Wave-Lengths between the Longest Thermal and the Shortest Electric Waves yet Measured.

E. L. Nichols, Standards of Light.

H. Pender, The Magnetic Effect of Moving Charges.

M. I. Pupin, Electrical Impulses and Multiple Oscillators.

E. B. Rosa and F. W. Grover, The Absolute Measurement of Capacity and Inductance.

E. Rutherford, Radioactive Change.

J. Trowbridge, Spectra of Gases of High Temperatures.

A. G. Webster, Report on Recent Developments in Electrical Theory.

Frank A. Wolff, The So-called International Electric Units.

J. Zeleny, The Discharge from Points.

Other Sections.

From the programme of sections B, D, E, F, G, H we give those papers which should be specially interesting to our readers:

Section B—M. A. Nodon, Electrolytic Rectifiers.

Section D—H. W. Buck, Use of Aluminium as an Electrical Conductor.

Section E—A. Wright, Recent Improvements in Electrolytic Meters.

Section E—G. Goettling, Storage Batteries.

Section E—H. N. Potter, Nernst Lamps.

Section E—C. P. Steinmetz, Luminous Electric Arcs.

Section F—J. B. Entz, The Storage Battery in Electric Railway Service.

Section G—G. F. Sever, Electrolysis of Underground Conductors.

Section H—S. Schatzky, The Ionic Theory as Biological Basis for the Therapeutic Action of Electricity.

Section H.—Margaret A. Cleaves, The Nature of the Changes Established in Living Tissue by the Action of Oxidizable Metals at the Anode.

Section H—J. W. Langley, Electric Purification of Water for Drinking.

Section H—Jacques Loeb, Control of Life Phenomena by Electrolytes.

The Government of the United States, at the petition of the Committee of Organization, has issued invitations to the various foreign governments to send official representatives to the Chamber of Delegates of the Congress. Up to the present time the following appointments have been announced:

Austro-Hungary—Prof. Charles Zipernovzky.

Italy, Prof. Moise Ascoli, Prof. L. Lombardi, Ing. A. Maffezzini.

Switzerland, Prof. Ferdinand Weber, Prof. Francois Louis Schüle.

Norway and Sweden, Prof. Svante August Arrhenius.

Australian Colonies, John Hesketh, Esq.

Brazil, Señor Jorge Newbery.

India, J. C. Shields, Esq.

Mexico, Señor Rafael R. Arizpe.

United States, Prof. H. S. Carhart, Dr. A. E. Kennelly, Prof. H. J. Ryan, Prof. S. W. Stratton, Prof. Elihu Thomson.

ST. LOUIS EXPOSITION.

International Acheson Graphite Co.

The exhibit of the International Acheson Graphite Co. is located in section 1, head of aisle "S", in the Electricity Building, and consists of specimens and samples of the two distinct branches of the business of this company, viz., the electrodes and the bulk graphite. These specimens illustrate not only the products as manufactured by them, but also show the various lines of work in which Acheson graphite is proving successful as compared with the natural graphites.

There are also shown four miniature electric furnaces, which are exact duplicates of those used at Niagara Falls, and illustrate various stages in the process of manufacture. One of these furnaces, by the use of gas, illustrates a furnace in actual operation, the gas burning and playing over the surface of the mixture and walls in the same manner as in the larger furnaces at Niagara Falls. Another shows part of the mixture covering removed, exposing the red-hot core. Still another shows the graphite ready to be unloaded and the fourth the method of loading the electrodes into the furnaces for graphitization.

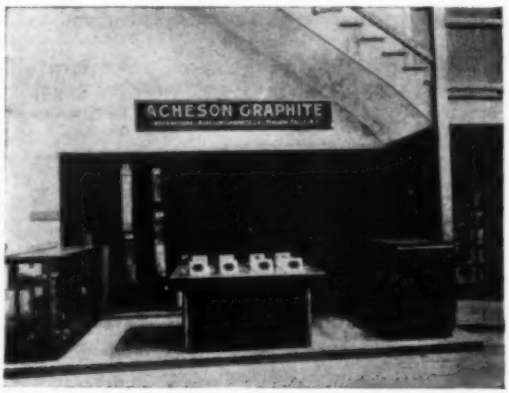


EXHIBIT OF INTERNATIONAL ACHESON GRAPHITE COMPANY.

With respect to the specimens of electrodes, we may refer to their full description in an article by Mr. C. L. Collins, 2nd, published on page 277 of our July issue. In connection with the bulk graphite exhibits, the company illustrates the use of Acheson graphite in the manufacture of paint, stove polish, dry batteries, motor brushes, etc. A special feature is made of the use of Acheson graphite in high-grade protective coatings for structural iron and steel. For this purpose it is stated to be ideal, and is gradually becoming the standard graphite pigment in this country. In some recent tests made by the National Tube Works of McKeesport, an Acheson graphite paint was awarded the highest merit, and is to be used exclusively upon their new plant, covering some eighty acres of ground; these tests extended over a period of eighteen months, and included eighty-three different varieties of protective coatings.

Carborundum Co.

The very attractive and conspicuous exhibit of the Carborundum Co. is on block 16 of Machinery Hall, near the eastern entrance to the building. Raw carborundum, as it comes from the electric furnace (see full description in Electrochemical Industry, vol. I., page 50, 1902), in beautiful crystals, is exhibited in form of a revolving huge pyramid ten feet in height by five feet in diameter at the base. This column of crude carborundum is placed in a most artistic circular pavilion. Around it, the specimens of work done with carborundum are exhibited in showcases. Many exhibits deal, of course, with the various applications of car-

borundum for grinding purposes. A model of Mr. Acheson's electric furnace for making carborundum is exhibited in the Mines and Metallurgy Building. Another special feature is the exhibit of metallic silicon made by the Carborundum

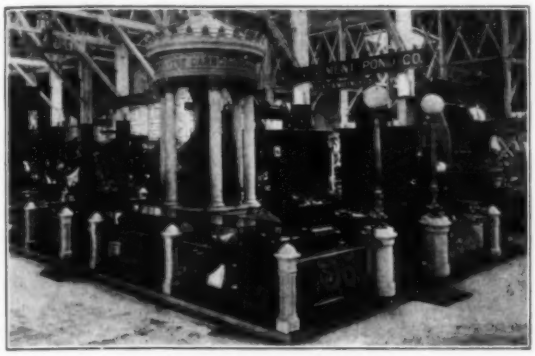


EXHIBIT OF CARBORUNDUM COMPANY.

Co. by Mr. Tone's electric furnace process; it will undoubtedly interest metallurgists. It contains 97 per cent of metallic silicon.

ELECTRIC STORAGE BATTERY CO.

The exhibit of the Electric Storage Battery Co., is a model battery plant, constructed on exactly the same lines as one forming part of a power house or sub-station. Above this model plant a large map of the United States is suspended, indicating the locations of each of the 1700 storage battery installations which have been made by this company. Spots of different colors indicate the special purpose for which the batteries are employed. There are also shown complete cells for railway work, such as are installed for the St. Louis Transit Co., and cells for automobile work.

EDISON STORAGE BATTERY CO.

The Edison Storage Battery Co.'s exhibit occupies space adjoining the main Edison booth, which is divided into three sections; the central one is the headquarters of the American Institute of Electrical Engineers, while on the right and left are the offices of the Association of the Edison Illumination Companies and of the Edison historical exhibit, respectively.

The Edison Storage Battery Co. exhibits three of the latest types of the iron-nickel alkaline battery, with parts cut out from one side so as to show the internal construction. One case shows the different parts of the battery; another case contains a historical collection of cells from the first one made by Mr. Edison and showing one cell of each succeeding type. A 40-cell automobile batery is connected to a charging board to show the conditions under variable rate of charge and discharge and to demonstrate the high charge rates which the battery can stand. The exhibit also contains ten different types of the Edison-Lelande primary battery.

LANYON ZINC CO.

The exhibit of zinc and zinc products by the Lanyon Zinc Co. is located at Block 42B, Mines and Metallurgy Building, and shows the diversity of uses of that metal, and the ease with which it may be worked into many products, not only in the well-known electrical and household lines, but in the many small parts of modern manufacturing processes as well.

The Lanyon Zinc Co., though manufacturers of spelter, sheet zinc, zinc wire, tubes and band only, have gathered together a large number of the manufactured articles for which they supply the material. A handsome cornice and pediment worked up from sheet zinc is a principal feature of the exhibit and forms a background to the space over sixty feet long. The various panels of this are decorated with views of the company's spelters and mills, and at either end stands a grotesque griffin stamped from sheet, these latter being excellent examples of the use of sheet zinc for statuary.

Upon the two large columns which are located symmetrically near the corners of the exhibit, are displayed handsome stamped zinc lions' heads and ornaments, church organ pipes of zinc, a large washboard showing the various styles of ribbing used in standard makes, a section of a flight of stairs, showing in a graphical manner the use of zinc stair treads, nosings and stair corners, white bronze medallions, as well as the name and location of the company arranged in stamped zinc letters brightly burnished. Piles of spelter, a number of casks of sheet zinc, a box of flat sheets, and a table of corrugated zinc, with a large display of wire rods, tubes and bands on reels and in the several show-cases, display the direct products of the Lanyon Zinc Co. Besides these are shown battery parts, organ pipes, zinc nails for roofing purposes, zinc roofing tile, corrosion-preventing plates for marine and stationary boiler use, zinc cable hangers, cyanide discs, fruit jar tops and bottle top specialties, dry battery cups, etc. Galvanized sheets and various articles should not be omitted from mention, as 50 per cent of the spelter produced in this country is consumed for galvanizing purposes.

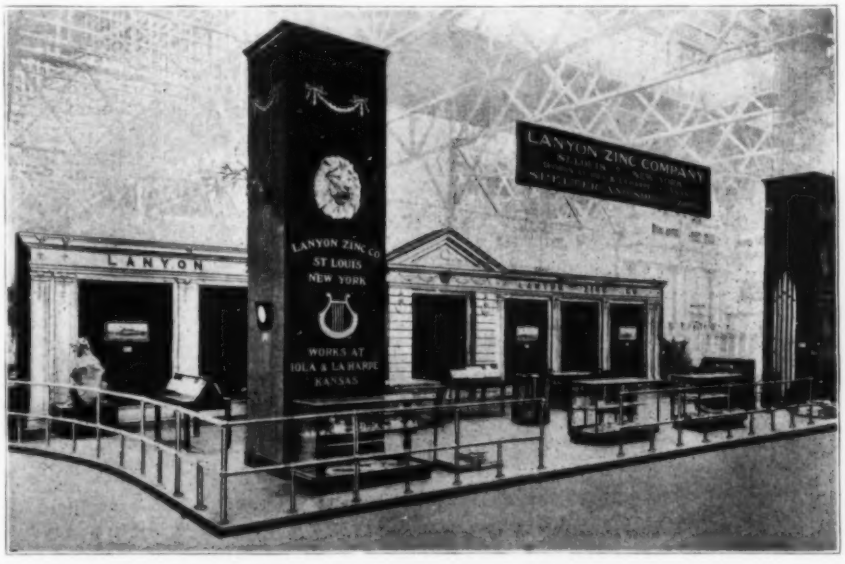


EXHIBIT OF LANYON ZINC COMPANY.

The brass trade is represented by the brass posts of the railing surrounding the exhibit, the horizontal rails of which are composed of pure zinc tubing, making a pleasing combination of colors. In fact, the ever-widening avenues of zinc consumption are excellently represented.

In addition to this main exhibit the company is also represented in the Metal Pavillion at the end of the Mining Gulch, which building they roofed with zinc, for which purpose zinc seems specially adapted, on account of its remarkable durability. This building is also lined with corrugated sheet zinc which is coming more and more into favor for factory buildings, train sheds, warehouses and the like.

Goldschmidt Thermit Co.

The exhibit of the Goldschmidt Thermit Co. is located in the Metals Pavilion, a building opposite the south corner of the Mines and Metallurgy Building. The exhibit covers the whole of the aluminothermic process. The ignition of an appropriate mixture of metallic oxides and finely-divided aluminium results in the almost instantaneous reduction of the oxides to pure metals, with the development of an enormous amount of heat, so that temperatures estimated at about 5400° F. are easily produced without any supply of heat or power from outside. Concerning further details, the reader may be referred to the extensive descriptions of the applications of the process by Dr. Hans Goldschmidt in our issues of November, 1903, p. 527, and April, 1904, p. 145.

The exhibits of the Goldschmidt Thermit Co. may be roughly divided into two classes. The first is the display of pure metals, such as chromium, manganese, molybdenum, ferro-vanadium and others (free from carbon, because produced by reduction with aluminium). The second class of exhibits shows the application of thermit to welding iron and steel. The appliances used, consisting of crucibles and moulds, are shown in position, and a number of welded objects, such as girder rails, shafts, pipes, etc., demonstrate the efficiency and usefulness of the process. The process is also shown in actual use, and thoroughly explained by demonstration daily at 4 o'clock in front of the exhibition space. Mr. W. M. Carr is in charge of the exhibits.

The Roessler & Hasslacher Chemical Co.

Among the exhibits of American manufacturers in the chemical industries, that of The Roessler & Hasslacher Chemical Co. in the Palace of Liberal Arts deserves more than a passing notice, being most artistically designed and executed. This firm has conceived and carried out the unique idea to use the picture of an alchemist as the background for their exhibit, and thereby make the same interesting for every visitor, even if not concerned in the chemical line.

Their booth, 20 feet long, 20 feet wide, and 18 feet high, represents a building of massive stone construction of the Middle Ages, with a view through the large archway disclosing the interior of the alchemist's study and workshop, while in two windows on the side aisle a special feature is made of the ceramic colors and peroxide of sodium which they make, by showing actual specimens of work done with these two articles. The Old Alchemist scene is a reproduction from the well-known painting of the famous old master, D. Teniers, Jr., now at the Museum in Brunswick, Germany.

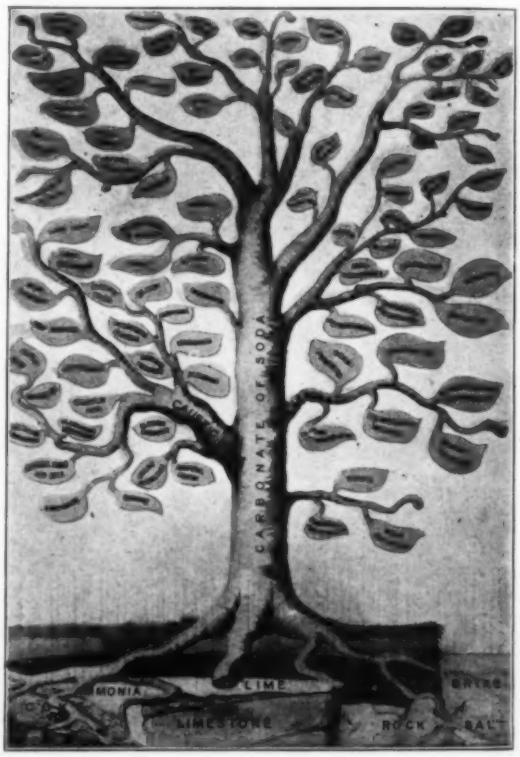
The Roessler & Hasslacher Chemical Co., who in 1884 started their works at Perth Amboy, N. J., to which they have since added materially, and also have an electrolytic plant at Niagara Falls, known as the Niagara-Electro-Chemical Co. (see Electrochemical Industry, vol. I., p. 14, 1902), have been the pioneer makers of a certain line of chemicals, among which are the following on exhibition. Acetone, which is a good solvent for fats, resins and camphors, and is used in the preparation of smokeless powder; chloroform; formaldehyde, a disinfectant, insecticide, preservative, which is coming into general use; metallic sodium, which is used in the laboratory and mining, and from which sodium cyanide is manufactured. The Roessler & Hasslacher Chemical Co., being the first in 1890 to start the manufacture of cyanide of potassium of 98 to 99 per cent purity, now produce a high grade cyanide of sodium, equivalent to 128 to 130 per cent cyanide of potassium. The cyanides are extensively used in electroplating and for the extraction of gold and silver from ores, tailings, etc.

In the ceramic window all shades of their enamel and underglaze colors, fluxes and metallic oxides for decorating in the china, clay and glass industries are shown, as also liquid bright gold; platinum and silver preparations which at once give after burning, without burnishing, a bright gold, platinum or silver surface.

The peroxide window is occupied entirely by the products of the textile mills, substituting the modern peroxide of sodium bleaching methods for the old and injurious process and method of bleaching with lime and sulphur. Recently the firm has also taken up the sale of metals, such as metallic chromium, magnesium, molybdenum and tungsten, and of the ferro-alloys of these metals which are coming into very extended use in making special steels, as is also high-grade ferro-silicon, 25 to 50 and 75 per cent, replacing the furnace-made products.

Mallinckrodt Chemical Works.

The exhibit of the Mallinckrodt Chemical Works, of St. Louis, is located in the southeast corner of the Palace of Liberal Arts, opposite the Government Building, in the section devoted to chemical, pharmaceutical and surgical instrument displays. The exhibit illustrates the advance made by this firm in the manufacture of pure chemicals for medicinal, photo-



TREE REPRESENTING THE MANUFACTURE AND THE USES OF CARBONATE OF SODA (SOLVAY PROCESS CO.)

graphic and other purposes. The main portion of the exhibit is installed in a massive mahogany case, 18 feet long, by 12 feet wide, completely enclosed with plate glass, which permits of an unobstructed view of the pretty effect produced by the multitude of specimens of chemicals put up in handsome cut-glass bottles, mushroom glasses, etc., many of which were especially made and imported for this display. The side of the case facing aisle G is, perhaps, the most attractive portion of the exhibit on account of the background being arranged with large plate-glass mirrors. In this division of the case are

placed the gold, silver and platinum salts, cocaine, caffeine, and a number of the rarer and more expensive alkaloids.

Among the numerous substances on exhibition are morphine, codeine, cocaine, strychnine, caffeine, carbolic acid, bismuth preparations, calcium salts, anaesthetics, mercurials, hydro-

EXHIBIT OF SOLVAY PROCESS COMPANY.

gen peroxide, iron preparations, pure granulated salts, salts of lithium, potassium, sodium, aluminium, etc. There is also a full exhibit of all kinds of chemicals used in photography.

SOLVAY PROCESS CO.

The exhibit of the Solvay Process Company, of Syracuse, N. Y., consists of good-sized samples of their various products, which are carbonate of soda, bicarbonate of soda, caustic soda, calcium chloride crown filler, and samples of raw materials from which soda products are made. The adjoining diagram shows a tree illustrating the method of manufacture of carbonate of soda and the great many compounds of organic and inorganic chemistry which are made from it. The exhibit is located in the New York section of the Department of Mining and Metallurgy. Above the samples of their products, various pictures are exhibited showing what the company has done to elevate the social condition of their workmen. These pictures represent the "Guild Hall," "Hospital," Dining-Room," etc.

AMERICAN HARD RUBBER CO.

The American Hard Rubber Co., of New York, has a very fine exhibit in the Palace of Liberal Arts at the intersection of aisles 7 and H, block 65. This company is showing acid pumps, piping, fittings, dippers, battery jars, etc., all made of hard rubber and designed especially for the conveyance of acids, chemicals and alkaline solutions.

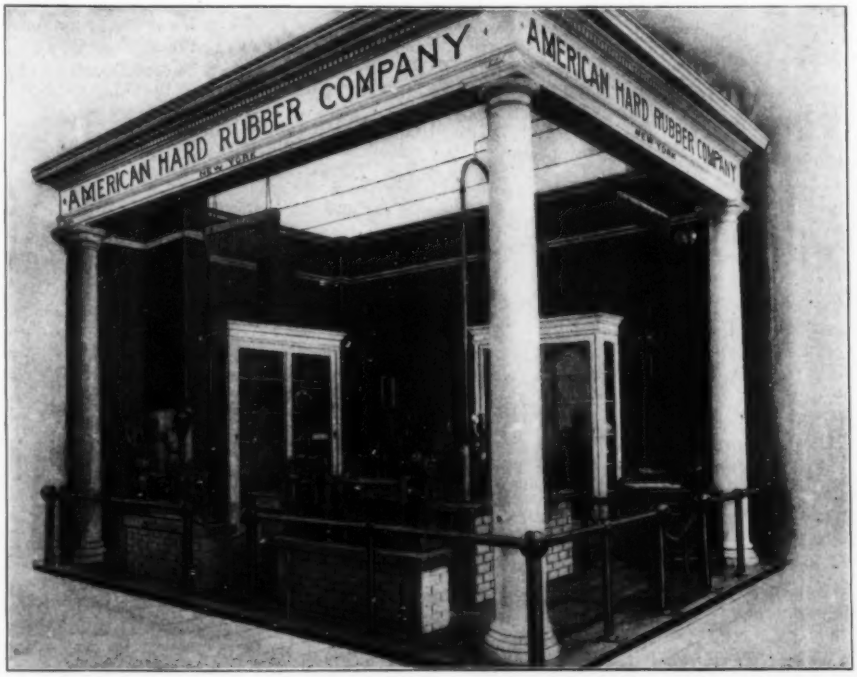


EXHIBIT OF AMERICAN HARD RUBBER COMPANY.

This exhibit should be of particular interest to chemical manufacturers, electrochemists, chemical engineers and all connected with chemical and electrochemical industries, on account of the well-known fact that hard rubber is impervious to the action of acids, etc., and practically non-corrosive.

ALLIS-CHALMERS & BULLOCK ELECTRIC MANUFACTURING CO.

These companies exhibit the largest generating set at the World's Fair. It is centrally located in the middle bay of the Palace of Machinery, and consists of the 5000-hp. Allis-Chalmers engine, and the Bullock alternator. It was installed, not only as an exhibit, but plays an important part in supplying power for the decorative lighting on the exposition grounds, and for other purposes. In the evening the set supplies current for nearly 200,000 incandescent lamps of 8 c. p.

The 3500-kw. Bullock generator which, like the engine, is capable of carrying a steady overload of 50 per cent, gives three-phase 25-cycle currents at 6600 volts, running at 75 r. p. m. This generator has attained a regulation within 6 per cent, while the engine can be regulated within 2 per cent.

LEEDS & NORTHRUP CO.

The Leeds & Northrup Co., of Philadelphia, have all of their apparatus and instruments exhibited as part of the exhibit of the National Bureau of Standards in the Electricity Building.

The National Bureau of Standards is making an extensive working exhibit, which, to a considerable extent duplicates their equipment at Washington, and it will maintain a large working staff at St. Louis. By arrangement with the authorities of the Exposition, it is to act in an official capacity in calibrating and standardizing instruments for the Jury of Awards, and in making tests for them. In order to have the necessary apparatus to make this working exhibit without depleting the equipment of the Bureau at Washington, various manufacturers have furnished apparatus and instruments for the exhibit of the bureau. Among them are the Leeds & Northrup Co. Among the apparatus exhibited by this company are resistance boxes and Wheatstone bridges, Carey Foster bridges, resistance standards, apparatus for measuring low resistances, potentiometers, d'Arsonval galvanometer, keys, condensers, self-induction apparatus, curve tracers, etc.

Of special interest should be the form of Kohlrausch slide

wire bridge, which was designed by the Leeds & Northrup Co., with the intention to have all the advantages of the original form of Kohlrausch bridge without its disadvantages. The latter are uncertain contact resistances in the bridge circuit, due to the brushes through which the current passes to the wire, and uncertain contact in the galvanometer circuit made by poor contact of the roller on the wire or of the roller on the rod on which it moved. To accomplish this, the contact is made movable and the polished cylindrical stone on which the wire is fastened is fixed. In this way both ends of the wire have reliable soldered connections out to the binding posts, and the connections in the contact circuit are also soldered, except that found between the long nut moving on a large screw which moves the contact arm up and down as it rotates. This, on account of its ample size, is entirely reliable. The wire makes ten turns around the stone cylinder and the total resistance is about 5 ohms. A vertical scale shows the number of turns, and the fraction of a turn is read from a circular scale, which is divided to 200 parts and can easily be estimated to tenths of a division. The advantage of the rubbing contact over the rolling contact of the original form is stated to be very marked, and to be entirely reliable.

Another very convenient and very carefully designed instrumnt exhibited by this company is their standard potentiometer.

Missouri Electric Water Purifier Co.

This company exhibits in the court of the Electricity Building the Kune process of purifying water, the electrolytic action of the anode producing an insoluble hydrate which coagulates the impurities in an insoluble mass, so that when the water has passed through a filter the impurities remain back. The purifier has a capacity of 500 gallons of purified water per day, the current consumption being 30 amperes at 15 volts.

Buffalo Forge Company.

As the Buffalo Forge Co., the Buffalo Steam Pump Co., and the George L. Squier Manufacturing Co. are under one management, their various products are exhibited collectively. Their booth is located in the Palace of Machinery, Group 62, Block 27, Aisle G. Due to the limited space, only a few of a complete line of engines for electric lighting and general power purposes are exhibited. Near the front of the display, in connection with the forge shop equipment, are blowing and exhaust fans direct-connected to electric drives. Fans are also shown that may be used for exhausting chemical fumes. Such fans have an interior construction that resists the action of the gases handled. (See Electrochemical Industry, August, 1904, p. 332.) One of the simpler types of the Buffalo Forge centrifugal pumps is included in the exhibit. These pumps can be built of hard lead, brass, etc., for use in chemical works, the material being such that it will not be affected by the liquid pumped.

There is also a large line of direct-acting steam pumps for water works, mine and other service, including jet condensers and air pumps. A fire underwriter pump of the very latest approved design forms a part of this company's display.

Those interested in the chemics of the manufacture of sugar will have an opportunity of seeing a complete line of machinery as manufactured by the George L. Squier Co. Their part of the exhibit also includes coffee-drying and rice machinery.

In addition to the regular exhibit, the Buffalo Forge Co. have installed extensive mechanical draft apparatus in the Steam, Gas and Fuels Building. The Heine, Cahall, Belleville & Niclausse boilers are using their equipment. The short stacks of the power plant here are in direct contrast to those at the Paris Exposition, where natural draft was depended upon. The many unique features of this apparatus will be extremely interesting to those not in touch with the latest developments along this line.

R. D. Wood & Co.

Messrs. R. D. Wood & Co., of Philadelphia, have exhibits at two different places of the Exposition. The first is found in the Steam, Gas and Fuel Building, or Power House, adjoining Machinery Hall. It includes a live or working exhibit of a 350-hp. producer gas-power plant on their well-known pressure system, and also a 25-hp. suction gas-power plant operating a 22-hp. gas engine (Nash engine).

The pressure plant furnishes producer gas to a number of gas engines in National Meter Co's. exhibit in Machinery Hall through a pipe line. This plant comprises one of the R. D. Wood & Co's. revolving ash table gas producers, equipped also with the Bildt continuous automatic feed, and, in the order of their connection from the producer, an economizer, scrubber, tar extractor, purifier and gas holder. As thus arranged the plant may operate on soft or hard coal.

In this R. D. Wood & Co. system arrangement is made through the economizer to return to the producer in the steam and air blast what would otherwise in cooling be a loss of heat by the sensible heat of the gas.

Another interesting feature is the attention paid to the minimizing of labor. The coal is received from the railroad car in a conveyor hopper, which conveyor carries it to the elevator boot from which the bucket elevator raises and discharges it into an overhead coal bin. By suitably arranged gates the attendant charges the storage magazine from this coal bin of the Bildt feed. The latter then continuously and uniformly feeds the coal to the producer. The coal handling is thus made, as far as practicable, automatic.

The suction producer plant presents a neat and compact appearance, having its gas generator and evaporation in one element. Then follows in order the scrubber and receiving tank, from which the engine draws its supply. As is understood, the forward stroke of the engine piston in this design of plant draws the requisite air through the fuel bed and the generated gas to the engine. The engine is used, as thus driven, in operating the coal elevator and Bildt automatic feed.

2333-KW TRANSFORMER. GENERAL ELECTRIC COMPANY.

These present a very interesting exhibit to those concerned in fuel economy in power generation, a horse-power per hour being secured with good gas engines on from a pound to 1¼ pounds of coal.

An 84-inch diameter pipe, bell and spigot, reminds the visitor that it comes from R. D. Wood & Co., Philadelphia, who, by the way, are the oldest manufacturers of such pipe in

the States. As it forms the vestibule, so to speak, of their exhibit space, many pass through it daily and many are the guesses as to its diameter.

A sectional cut through a cast-iron side-suction centrifugal pump gives a good idea of their construction and finish, which attracts much attention.

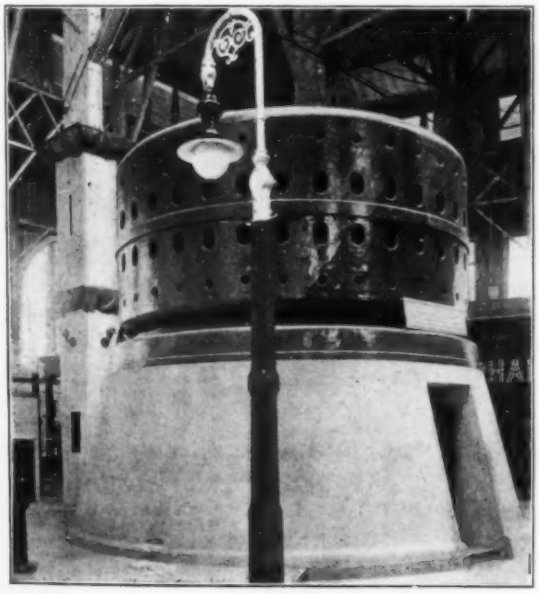
There are also exhibits of the R. D. Wood & Co. high-pressure hydraulic valves as used in the control of the hydraulic appliances made by the firm and extensively used in iron and steel industries where durability and nicety of adjustment with minimum repairs are important factors.

Messrs. R. D. Wood & Co. have also an exhibit at the United States Geological Survey's Coal Testing Plant in the "Gulch." This installation will be used in testing a great variety of soft coals bought by the Government for this purpose. It is essentially of the same construction as the plant above described, except in its coal handling. It will furnish gas to a 260-hp. Westinghouse gas engine.

OTTO GAS ENGINE WORKS.

The exhibit of the Otto Gas Engine Works, of Philadelphia, is located at space 41 of Machinery Hall, main aisles D and E, cross aisles 7 and 8. They are exhibiting 17 engines, consisting of all purpose engines, marine engines, farm or portable engines, hoisting engines, and engines specially built for electric light work. Eleven of these are piped up and running.

An installation which proves of special interest, is a 40-hp. single cylinder, " hit and miss" governed gas engine, directly connected to a 30-kw. generator. It furnishes current to several 110-volt enclosed arcs, and the main points of interest is the close regulation obtained, there being less than 3 volts variation under varying loads and extremely steady lights under partial load, as low as one-third. There is also on exhibition a 10-hp. gas engine, single cylinder, hit and miss



MODEL OF 10,000-HP VERTICAL SHAFT GENERATOR. GENERAL ELECTRIC COMPANY.

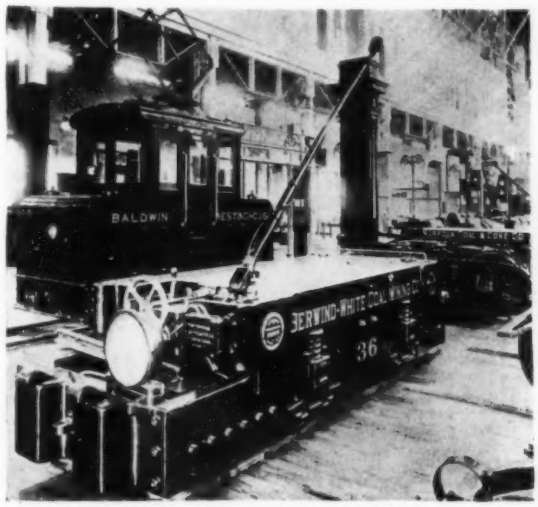
type, belted to a 6-kw. generator, which furnishes power to incandescent lights and fans.

These engines are of great interest for small isolated plants, since almost any form of gaseous or volatile fuels can be used. The space of the exhibit is lighted and cooled by power furnished by the gas engines.

STILWELL-BIERCE & SMITH-VAILE CO.

The Stilwell-Bierce & Smith-Vaile Co., of Dayton, Ohio, have the following apparatus on exhibition:

One 7000 square foot surface condenser, steel shell type, which is to be operated in connection with 1000-kw. steam turbine manufactured by Hooven, Owens & Rentschler, of Hamilton, Ohio; the maximum output of the turbine, with 50 per cent overload, is 33,000 pounds of steam per hour; the condenser must create, therefore, and maintain a vacuum of from 27 to 28 inches, based upon a 30-inch barometer, with a



BALDWIN-WESTINGHOUSE ELECTRIC LOCOMOTIVES.

temperature of refrigerating water not to exceed 80° F. A jumping engine and two vacuum pumps belong to this plant.

The company has also furnished for a vertical cross-compound Hamilton-Corliss engine, one 4000 square foot surface condenser of the rectangular and shell type, for condensing approximately 35,000 to 40,000 pounds of steam per hour maximum, and maintaining a vacuum of 26 inches and above, based upon a 30-inch barometer. The circulating pump is of the compound, direct-acting type, duplex pattern; the vacuum pump is of the combined wet and dry type.

The machinery is located within the confines of Machinery Hall, at the west end of block 45, immediately west of the north entrance of Machinery Hall. For the boiler plant various pumps were installed by the company, while they have on exhibition in the Mining Industries Building a special feed-water heater for a pump to be used in connection with gold-cleaning apparatus.

GENERAL ELECTRIC CO.

The exhibit of the General Electric Co. in the Electricity Building consists of very carefully selected examples of its latest and most representative work. A striking instance is the full-sized model of the 10,000-hp. vertical shaft generator for the Canadian power plant at Niagara Falls. Five of these machines are being installed, these being the largest dynamos ever constructed. The model represents the stationary armature of the machines resting on a concrete base.

Among the railroad exhibits is a 7-ton mining locomotive equipped with a cable reel which automatically winds as the locomotive advances or backs up. This new cable relay is a feature highly appreciated by mining engineers, since it allows electric locomotives to be run into new portions of the mine where trolley wires have not yet been installed; at the same time there is no danger of the cable becoming tangled up or run over by the locomotive, which frequently happens when the winding of the cable is left to the man operating the loco-

motive. The cable drum contains 700 feet of cable, and the locomotive automatically winds this up. The cable drum is geared to the locomotive axle through the medium of a friction clutch, which allows a certain amount of slip, but does not let the cable get entirely slack.

Among a great number of small motor applications are a 24-inch electrically operated Chapman valve, a centrifugal sugar-drying outfit with direct-connected vertical shaft motor, electric buffing and grinding machines, etc.

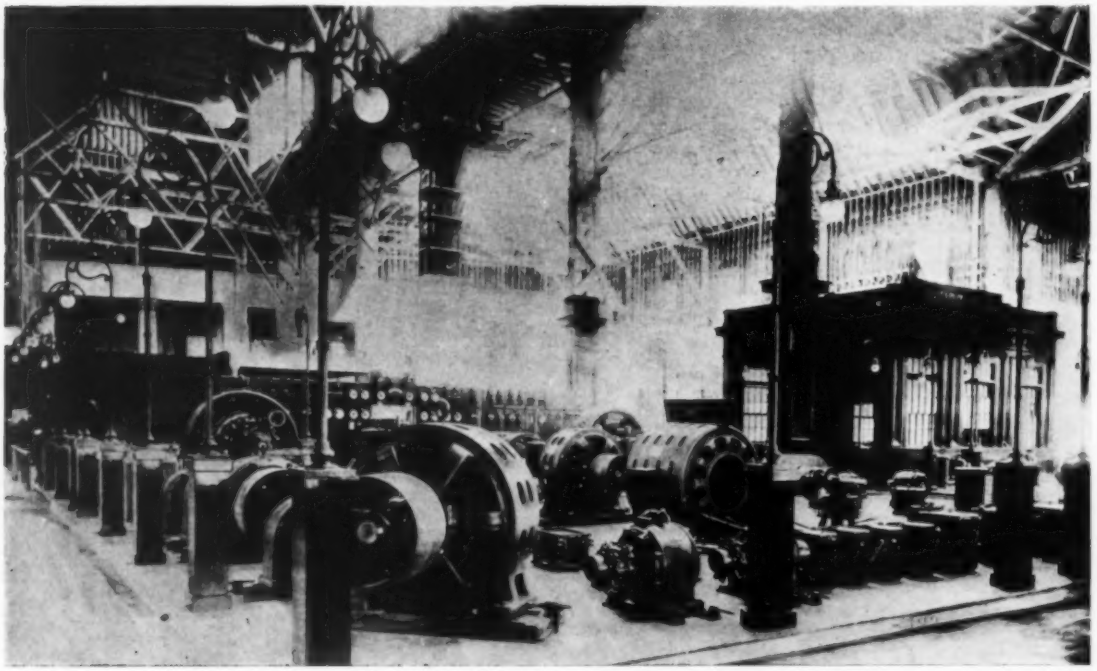
A special feature of the exhibit is the Steinmetz mercury vapor arc lamps which are here exhibited for the first time. There is also a mercury vapor rectifier with a capacity of 10 amperes direct current, shown side by side with a motor generator set for doing the same work, the cost of which, however, is double that of the mercury vapor rectifier.

The Westinghouse Companies.

The various organizations associated with the name of George Westinghouse have united in representation at St. Louis under the title of the "Westinghouse Companies at the Louisiana Purchase Exposition." The exhibits of these companies occupy a total of 65,620 square feet floor space. The main service plant of the exposition, for which the Westinghouse Electric and Manufacturing Co. received the general contract, comprises four big electric generating sets, each of 2,000-kw. capacity, located in the center aisle of Machinery Hall. In this hall, in addition to the generating plant and the main exhibit of the Westinghouse gas engines, turbo-generators, rotaries, exciters and motors in operation, is the Westinghouse auditorium with a seating capacity for 350 persons, in which are displayed at regular hours during the day the mutoscope pictures of scenes in and about the various works in Pittsburg. Through the courtesy of the companies this auditorium will be used throughout the fair as a meeting-place for scientific societies and technical congresses. The lighting of the hall is with incandescent lamps of the Sawyer-Man Electric Co., Nernst lamps, Bremer arc lamps, and Cooper-Hewitt mercury vapor lamps, all of which are used extensively throughout the Westinghouse display.

In the Palace of Electricity, the Westinghouse Electrical & Manufacturing Co. occupies the space of over 10,000 square feet, including 1,600 square feet devoted to the display of electric trucks and locomotives, constructed in conjunction with the Baldwin Locomotive Works. Two locomotives built for mine services are shown, one weighing 20,000 and the other 30,000 pounds, each equipped with two No. 75 motors at 500 volts.

An important part of the Westinghouse installation is the pumping apparatus under the beautiful cascades in front of Festival Hall, supplying 90,000 gallons of water per minute for the cascades, by three large centrifugal pumps each driven by a 2,000-hp. Westinghouse induction motor. These are probably the largest motors ever constructed. Of the enormous number of highly interesting exhibits of the various Westinghouse companies, we have been able to mention only these few which should prove of special interest to our readers.



CORNER VIEW OF WESTINGHOUSE ELECTRIC MANUFACTURING COMPANY EXHIBIT.

Crocker-Wheeler Co.

The power plant of the intramural railway, situated in block 42, Machinery Hall, near the main entrance of the building, is the chief exhibit of Crocker-Wheeler Co., of Ampere, N. J. The electric generating equipment consists of seven operating units with a combined capacity of 3500 kw. Six of the generators, with an output of 900, 600, 500, 500, 500 and 400 kw., respectively, are driven by engines of various types, two being of horizontal cross-compound form, two vertical cross-compounds, one horizontal tandem compound, and one a large simple engine.

The last generating unit in the series is of an entirely different type, consisting of a 100-kw. generator, driven at a speed of 700 r. p. m. by a water-wheel operating under a pressure of 300 pounds per square inch at the nozzle. The water-power is supplied by a pump with a capacity of 1200 gallons of water per minute. The water-wheel is furnished by the Abner-Doble Company, of San Francisco, and the pump by the Jeanesville Iron Works Company.

With the exception of differences in size and in details of proportion, the several generators are similar. The machines

are compact, and great care is given to the design of the electrical and magnetic circuits. All parts are constructed with a view toward simplicity, effectiveness and steadiness of operation under continuous heavy loads or rapid load fluctuations. At the close of the Exposition these power units will be available for shipment to any part of the country.

NORTHERN ELECTRICAL MANUFACTURING CO.

The exhibit of the Northern Electrical Manufacturing Co., of Madison, Wis., is located in section 14 of the Palace of Electricity, and is devoted to an illustration of variable speed motor operation of machines and tools.

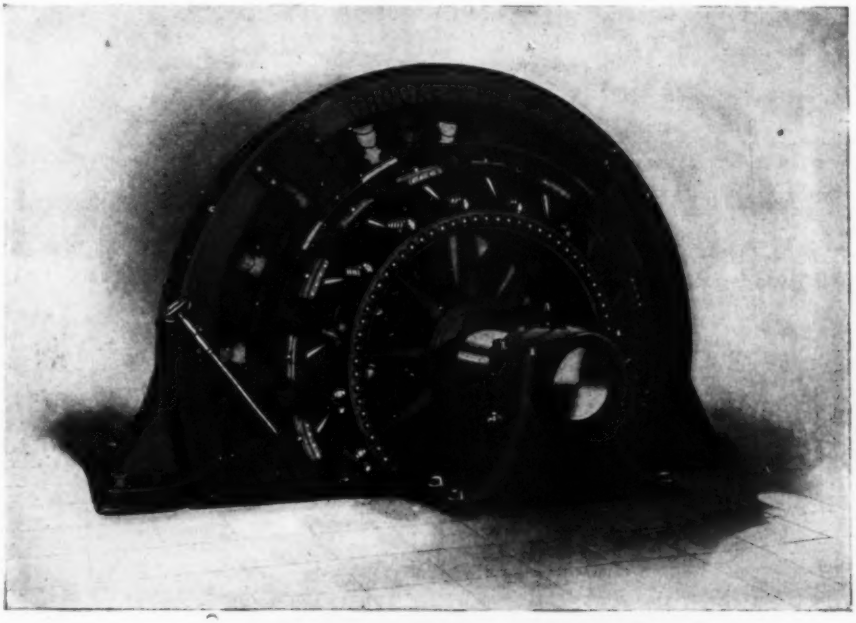
The exhibit includes a full line of Northern direct-current motors from ⅛-hp. to 50-hp., and a 75-kw. generator. Additional to the standard spherical motors shown, are Northern crane motors built in box-type frames, ranging from 1 hp. to 25 hp., and a Northern square elevator motor at 10 hp., with a speed variation of 2 to 1.

An item of especial interest to our readers is the 4-hp. Northern dust-proof buffer. This is a self-contained, variable speed equipment, comprising a special Northern dust-proof motor mounted upon a suitable stand in which is contained the motor starter and speed-varying device. The exhibit also includes three Northern dust-proof grinders of the same general characteristics as the buffing lathe with special features adapting them for grinding service.

EXHIBIT OF NORTHERN ELECTRICAL COMPANY.

The machine tools in the exhibit driven by Northern variable speed motors are all in operating condition and afford variations as high as 2 to 1, with current derived directly from the Exposition Company's two-wire single voltage power circuit. The machine tools include various lathes, boring and milling machines, shapers, drills, cutters, etc.

The constant-speed motors in the exhibit operate various fans, drills, grinder, shapers, pumps, etc. Scattered through the grounds in the exhibits of the manufacturers of machinery are located a number of Northern constant-speed and variable-speed motors driving grinders, pipe threading machines, milling machines, engine lathes, cutter grinders, automatic screw machines, turret lathe, vertical boring mill, horizontal boring mill, floor-surfacing machine, corn crusher and grinder, magnetic ore separators, oil compressors, and a rope tramway.



CROOKER-WHEELER 750-KW. GENERATOR.

NATIONAL ELECTRIC CO.

The National Electric Co., successor to the Christensen Engineering Co., Milwaukee, have an extensive exhibit in Section 6 of the Electricity Building. A 400-kw. direct-current engine-type generator is the largest unit shown at this space; a 150-kw., 500-volt, direct-current generator is driven by a 20-hp., 220-volt motor, and in addition to these there is in operation a 150-kw., 3200-volt alternator, a 10-kw. motor generator set, and a 60-kw., 500-volt, direct-current generator belted to a 30-hp., 220-volt motor.

A three-car train shows the operation of their air brake control. Stationary and portable air compressors are also shown.

EXHIBIT OF NATIONAL ELECTRIC COMPANY.

At block 46, of the Machinery Building, may be seen the National 1500-kw., 6600-volt, three-phase, 25-cycle alternator, running at 85 r. p. m. This generator is directly connected to a 2250-hp. engine and furnishes power for the immense

streams of water which flow over the cascades, the largest artificial water falls in the world. This generator is of the revolving field type, and, at unity power factor, it has an efficiency of 95.5, 95.5 and 94.75 per cent at 1¼, full and half load, respectively. For a power factor, equal to unity or zero, the regulation is 5.5 or 22 per cent, respectively.

Electric Controller & Supply Co.

The exhibit of the Electric Controller & Supply Co., of Cleveland, Ohio, is found in section 5, space 28 of the Palace of Electricity. The striking feature is the direct motor drive for planers. This drive brings the planer to the same high efficiency as the motor-driven lathe. The motor is geared direct to the cross-shaft, and instant change and control of speed is obtainable without changing gears or stopping the planer.

A new system of control specially adapted to mill table motors is shown in operation. This controller makes it impossible to injure the motor by "plugging."

Several distinct lines of crane controller are shown. These controllers are specially designed to withstand the rough handling, usually the lot of such apparatus in mills and factories. They are all built with the resistance self-contained. All parts are easy of access for inspection, and wearing parts are made renewable, thus cutting the repair expense to a minimum.

A line of knife switches, cast grid resistance banks, solenoids, magnetic friction and stop brakes and crane fittings are shown, and a working exhibit of the "Clark" lifting magnet. This magnet is suspended on a Brown Hoisting Machinery Co. tramway hoist, and will be of special interest to those who have billets, slabs or plates to handle.

Lidgerwood Manufacturing Co.

The standard hoisting engines and hoisting and conveying apparatus, exhibited by the Lidgerwood Manufacturing Co., of New York City, have been carefully selected so as to avoid the warehouse idea as much as possible. Since this company makes practically every class of engine employing a winding drum, whether operated by steam or electricity, and has built hundreds of varieties of special engines for every conceivable kind of hoisting service (having manufactured up to the present time over 23,000 hoisting engines, boilers and electric hoists), the standard types exhibited represent relatively few styles only, but they are well-selected, so as to give a good idea of workmanship and design. Most of the exhibits of the Lidgerwood Manufacturing Co. are located in sections 30 and 34 of Machinery Hall.

Among the various machines exhibited the following should be of special interest: A ship winch for use on two U. S. battleships, driven by a 40-hp. electric motor; a standard double-drum engine with latest form of apparatus for swinging the boom of an ordinary derrick, while simultaneously the boom is being raised and the load hoisted; a small single-drum engine for miscellaneous hoisting work in docks, warehouses, etc., and also useful for small mining work; an erection and pile-driving engine, combining with the double-friction drums

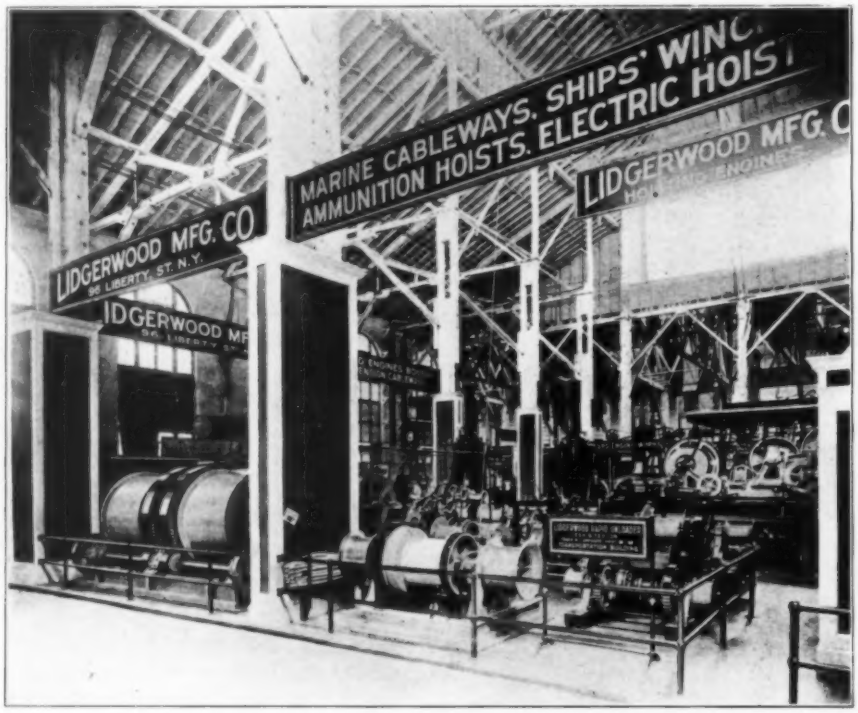


EXHIBIT LIDGERWOOD MANUFACTURING COMPANY.

necessary for pile-driving or derrick work, four independent winch heads for bridge and erection work; a belt-driven hoist, etc.

Among the hoists specially designed for mining, is a standard type of reversible link-motion mine hoist, rated for a load of 3000 pounds to be hoisted at a speed of 350 feet per minute. There is also exhibited an electric mine hoist of a very simple and useful type, since it may be used either as a reversible hoist or as a friction-drum hoist, in the latter case using the power for hoisting and lowering by means of the loose friction drum with the brake. Of great interest is also a double-drum mine hoist; it is an engine designed for either double compartment shafts or for inclines and rail-rope haulage; it is very flexible, for the drums may be thrown into gear, and it may then be used as a regular reversing engine, or the drums may be operated independently by means of the frictions. For tail-rope haulage, one drum winds in the main rope, while the other is loose and pays out the tail-rope under control of the brake.

There are also exhibited models of the Lidgerwood interlocking skidder and of the Lidgerwood traveling cableway, while in the Transportation Building, on track 14, opposite post 65, the Lidgerwood ballast unloader is exhibited, in use for ballast unloading by all the principal railroads of this country and Canada.

LUNKENHEIMER CO.

In the Machinery Hall, location -5 G-Block 26, is the exhibit of the Lunkenheimer Company; it is easily identified by a large model of their familiar valve in hand, which occupies a prominent corner of their exhibit. Pyramids of globe, angle, cross, lever and gate valves, of various designs and sizes, both brass and iron, are artistically arranged about the exhibit.

The glass cases arranged in front of the exhibit contain a smaller class of the goods manufactured by them, such as lubricators, oil and grease cups, cocks, etc., of all sizes. Neat designs of racks containing various sizes of whistles, injectors, pop valves and a variety of other specialties lend to make up an exhibit worthy of notice. A new design of water gauge, and oil-pump for cylinder lubrication, are features in themselves. Dispersed about the exhibit are pipe fittings of every description, together with whistles, safety and check valves and numerous other appliances.

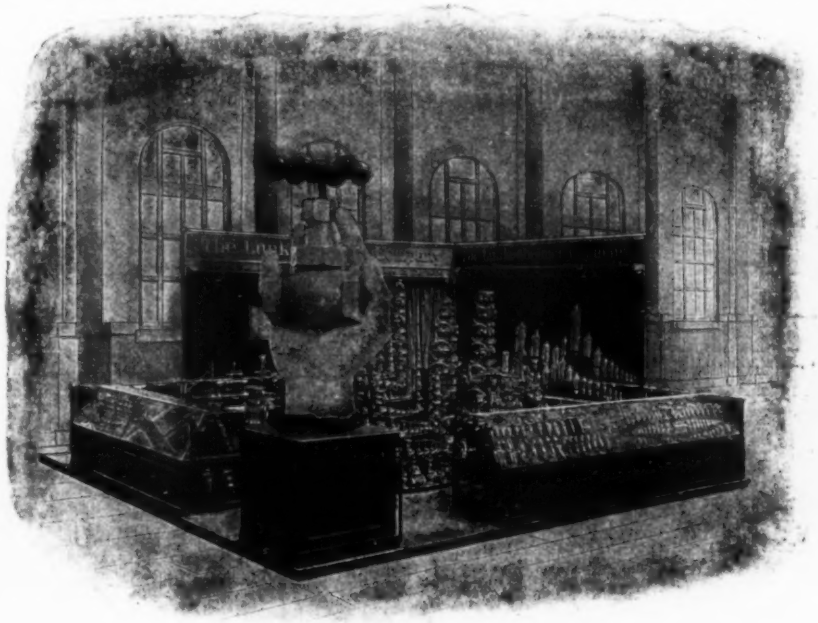


EXHIBIT OF LUNKENHEIMER CO.

BRIEF NOTES.

The NILES-BEMENT-POND CO. have a very extensive exhibit of machine tools in sections 17 and 25 of the Palace of Machinery. All machines exhibited are either of entirely new designs or embody radical modifications of older patterns. All the larger machines are driven by direct-connected motors. There is also exhibited a Niles 40-ton electric traveling crane.

The PRIMOS CHEMICAL CO., of Primos, Pa., has an exhibit in block 31 in the Mines Building, in the Department of Mines and Metallurgy. Their exhibit consists in the main of ores of tungsten, and the products made therefrom, such as tungstate of ammonia, tungstate of soda, tungstic acid, ferro-tungsten, tungsten metal, etc. The exhibit also contains molybdenum ores and products therefrom, like ferro-molybdenum, molybdenum metal, etc.

The C. O. BARTLETT & SNOW CO., of Cleveland, Ohio, have an exhibit of one of their style C, No. 3, four-compartment, direct-heat rotary dryers in the Government Testing Plant for determining the value of the different coals, and especially the lignite coal in that building.

The BAUSCH & LOMB OPTICAL CO., of Rochester, N. Y., have no exhibit of their own, but a great many of their optical instrument and chemical apparatus are exhibited by larger dealers.

Messrs. EIMER & AMEND, of New York City, have an exhibit of nickel laboratory ware in connection with the exhibit of the International Nickel Co., and an exhibit of radium, electric furnaces and pyrometers in the Department of Mines and Metallurgy, block 40. Various of the European manufacturers whose specialties this firm deals with are directly represented by exhibits.

The ZUCKER & LEVETT & LOEB CO., of New York City, are exhibiting nickel anodes and nickel salts in connection with the exhibit of the International Nickel Co., showing various forms of nickel anodes, flat and corrugated, with and without patent hook.

The LAGONDA MANUFACTURING CO., of Springfield, Ohio, have a very complete display of their cleaners, boiler-room and steam specialties in the Steam, Gas and Fuel Building.

The booth of the WESTON ELECTRICAL INSTRUMENT CO. is one of the most beautiful in the Electricity Building. It contains a very fine display of the Weston standard electrical instruments.

The booth of the NATIONAL CARBON CO. is made entirely of immense blocks of carbon cut in the form of columns, arches, etc., and set together like large timbers.

The LABORATORY & SCHOOL SUPPLY CO. (the New York branch of the Vereinigte Fabriken f. Laboratoriumsbedarf, of Berlin) have an extensive exhibit of chemical and physical laboratory apparatus and instruments (among them Luepke's apparatus for electrochemical work) in connection with the Educational Laboratory exhibit of the German Government, Department of Education, in the Electricity Building, section 35. They also exhibit a complete equipment of a chemical laboratory for an agricultural experimental station in the Palace of Agriculture, German Division, block 131.

Though the WARD LEONARD ELECTRIC CO. are not themselves exhibitors, a large number of apparatus of their make are used in the exhibits of other manufacturers, especially motor starters, field rheostats, circuit breakers, etc.

The WILLARD STORAGE BATTERY CO., while having no special exhibit, have installed all of the batteries that are running electric launches there; the service is stated to have been quite successful.

The DENVER FIRE CLAY CO. has an exhibit of their goods at the Metal Pavilion. This company handles a large variety of apparatus, used by chemists, assayers and metallurgists, including muffle furnaces made for both coal and wood. apparatus for use in the extraction of precious metals by the cyanide process, etc.

PERSONAL.

Dr. Willis R. Whitney, professor of theoretical chemistry at the Massachusetts Institute of Technology, has resigned to take full charge of the research laboratories of the General Electric Co.'s works in Schenectady, with which he has already been connected for some time.

Dr. Hans Goldschmidt, the distinguished inventor of aluminothermic methods, sailed from Europe on August 23, by the steamer "Moltke," and will attend the International Electrical Congress at St. Louis as the official delegate of the Bunsen Society. On the request of the authorities of the Congress, Dr. Goldschmidt will deliver a lecture on aluminothermics, with numerous demonstrations at one of the evening sessions. Provisionally, the date has been fixed for September 13, to take place in the hall of the Westinghouse Co.

OBITUARY.

William Weightman, of the firm of Powers & Weightman, the well-known chemical manufacturers of Philadelphia, died at his home on August 25, at the age of ninety-one. Mr. Weightman was born at Grimsby, Lincolnshire, England, on September 30, 1813. In early youth he left England, at the suggestion of his uncle, John Farr, founder of the present firm of Powers & Weightman, and came to Philadelphia, entering the service of his uncle as clerk, which position he occupied until 1836, when John Farr associated with him in the business Thomas H. Powers and his nephew, William Weightman, under the firm name of Farr, Powers & Weightman. After the decease of Mr. Farr in 1847, the firm became Powers & Weightman. Since that time the business of the firm has extended enormously. Since his two sons died, years ago, his only surviving child is Mrs. Anne M. Walker, who is now the only member of the firm of Powers & Weightman.

DIGEST OF U. S. PATENTS

Prior to July, 1902.

Compiled by Byrnes & Townsend,
Patent Lawyers,
National Union Building, Washington, D. C.

Electrolysis of Molten Sodium Salts.

(*Continued from page 334.*)

623,691, April 25, 1899, Charles E. Acker, East Orange, N. J.

Electrolyzes molten sodium chloride on a cathode of molten lead. The cell comprises an annular electrolyzing chamber with magnesia walls; a central alloy-receiving chamber with a wrought-iron partition wall jacketed with magnesia, and a cast-iron bottom, with a central outlet from the alloy chamber to the outer bottom edge of the electrolyzing chamber, and an annular passage below the partition wall. A screw in the central outlet forces the depleted lead from the central chamber out under the molten salt in the annular chamber, where it receives more sodium and returns beneath the partition to the alloy chamber. The richer, lighter alloy rises to the top of this chamber and passes down through an escape pipe, but part of the sodium vaporizes and escapes through an upper passage to a condenser, the movement of the sodium vapor being facilitated by a current of nitrogen derived from the deoxidized air in the apparatus. The nitrogen is returned from the sodium condenser to the alloy chamber. The proportion of vaporized sodium may be increased by keeping the alloy at a higher temperature. The connection to the lead cathode may be constructed as a heater, a resistance rod of carbon being protected by an iron sheath. Lead is supplied to the cathode from a separate pot. The cell is closed by a tile cover which supports the salt supply. The preheated salt is fed through holes having stoppers; it serves to seal the joints between the cover and the carbon rod anodes.

623,692, April 25, 1899, Charles E. Acker, East Orange, N. J.

Same apparatus as in preceding patent. Tin or zinc may be substituted for lead, as cathode. May treat the alloy with steam or air.

649,565, May 15, 1900. Charles E. Acker, East Orange, N. J.

Electrolyzes molten sodium chloride on a thin layer of lead, as cathode, flowing from an inlet at one side of the bottom of the cell to an outlet at the other side. At one end of the cell is a well which receives the products and returns the depleted lead to the cell. The sodium is oxidized by injecting steam either into the passage which conveys the alloy to the well, or into the well itself. The cell is a cast-iron vessel lined at the sides with magnesia. It has a fire clay cover with holes and two-part rings receiving the carbon rod anodes. The supply of salt rests on the cover and is fed in through stoppered holes. The modified cell employing an oxidizing well delivers alloy to the lower end of the well and receives the depleted lead from its upper end. A steam pipe depends nearly to the bottom of the well, and the rising steam oxidizes the sodium, thus supplying heat, and effects the circulation of the lead. The molten caustic overflows from the upper end of the well into a packing drum. When oxidation is effected by injecting steam into the passage which delivers alloy from the cell, the well is used as a settling chamber. The hydrogen may be burned to melt salt in a separate vessel.

663,719, December 11, 1900, Hermann Becker, Paris, France.

Electrolyzes molten compounds of light metals. The cell is a metal vessel having a tubular bottom extension in which is a sleeve of lava, porcelain or fire clay, receiving the terminal stem of the metal cathode. The extension is surrounded by a water-jacket, which produces a plug of solidified electrolyte to prevent leakage around the stem. The cathode consists of one or several upwardly-tapering bars, from which the deposited metal easily detaches itself and rises into a conical air- or water-cooled collector above. This collector is of metal and is constituted a supplemental cathode by a high-resistance shunt connection. The metal is delivered through a lateral pipe. The anode is a ring of carbon or metal, surrounding the cathode.

674,691, May 21, 1901. Charles E. Acker, Niagara Falls, N. Y.

The apparatus of his prior patent, 649,565.

679,253, July 23, 1901, Alfred H. Cowles, Cleveland, Ohio.

Electrolyzes compounds of volatile elements, *e. g.*, sodium, potassium, zinc, phosphorous. The cell is an iron vessel, the sides of which are lined with the solidified electrolyte. The false bottom and cathode is a horizontal plate of porous carbon, below which is a condensing and collecting chamber. The element deposited on the cathode vaporizes and passes through it and is collected below. For the production of sodium, may use a haloid salt or a mixture of sodium fluoride and aluminium fluoride, to which may be added sodium carbonate. The oxidation of the carbon anode may produce sufficient electrical energy to effect decomposition, the dynamo simply raising the potential to a point sufficient to overcome the resistance of the electrolyte and maintain it molten. A cell having twenty carbon anode rods, each 2½ inches in diameter, requires 3000 amperes at 5 volts. The cathode plate is preferably a baked mixture of coke and coal tar or pitch.

687,709, December 3, 1901, Charles E. Acker, Niagara Falls, N. Y.

Electrolyzes molten sodium chloride in a cell having a molten lead cathode and a separate, oxidizing well receiving a jet of steam. The cell is similar to that of his patent 649,565, except that the well has a screw on a central shaft, to control the circulation of the lead, which is effected in part only by steam injected through two pipes, one entering horizontally, the other upwardly.